MILITARY SYSTEMS DESIGN

NOVEMBER-DECEMBER 1961

featuring:

Air Bearing Rate Table

Engineered Protection for Inertial Guidance Systems

Servo Design Simplified

Brushless DC and Universal Motors

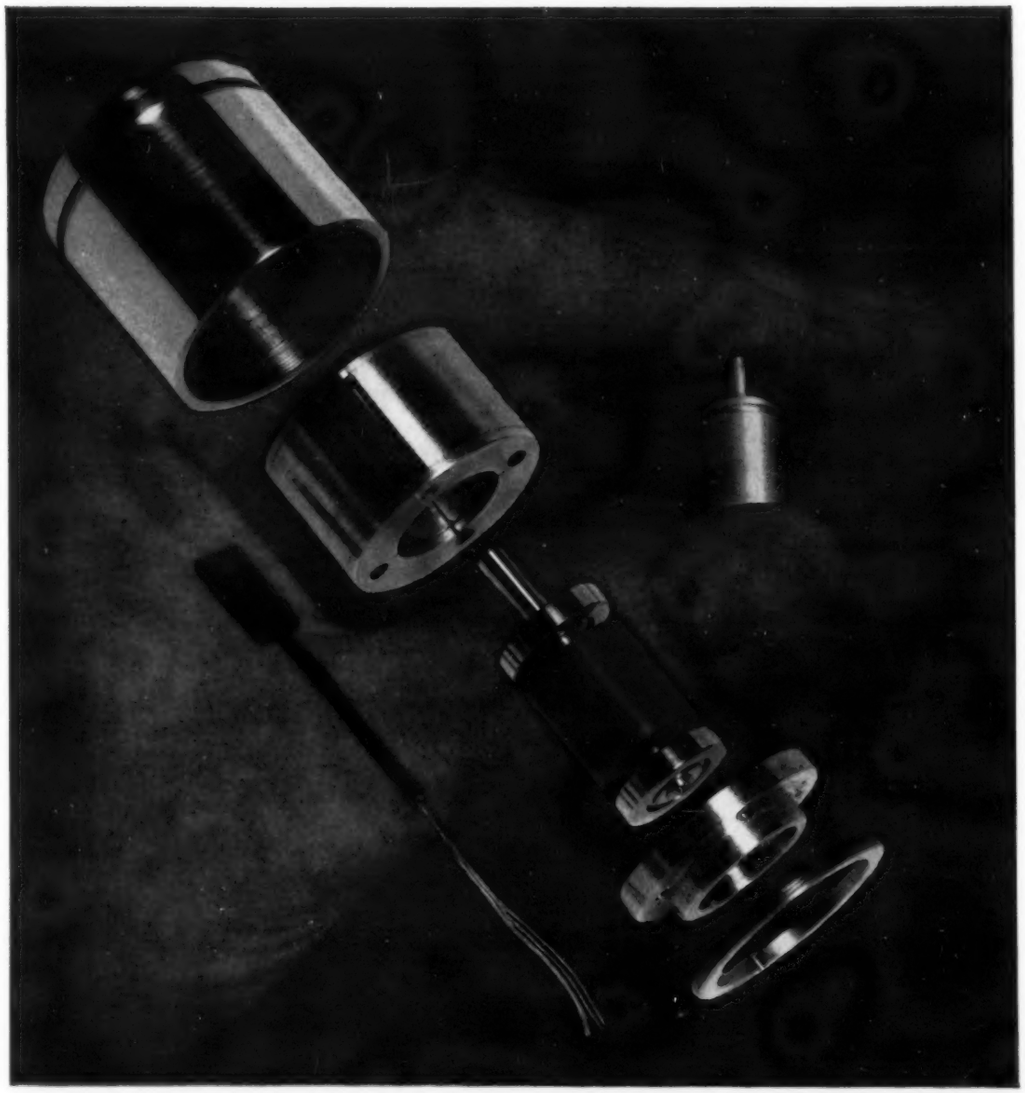
Multiple Testing of Electron Tubes—Automatically

Electronic Circuitry

cover article

Brushless and Windingless Components

ANNUAL INDEX VOL. IV 1961



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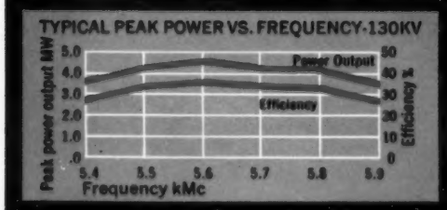

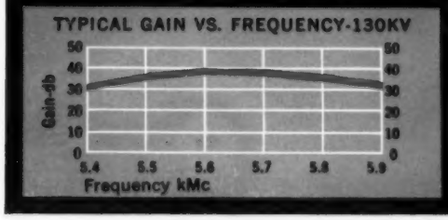

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VOL. 5, NUMBER 6
November-December 1961

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COVER: New semiconductor developments promising breakthroughs in the closely-related domains of inertial guidance and servomechanisms are detailed in the article (p. 4) on design of new Hall effect devices. Using neither brushes nor windings, these devices are particularly adapted to miniature rotating applications. A brushless technique for wound dc motor applications also is described in this issue (p. 34).

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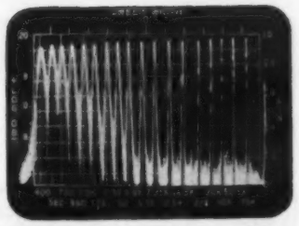

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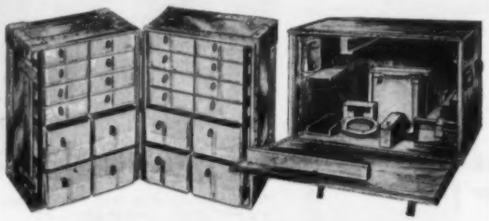

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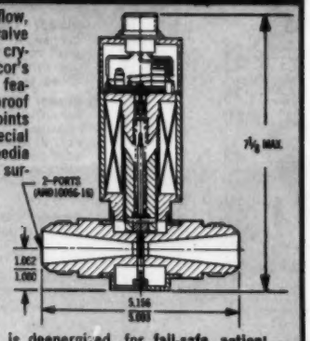

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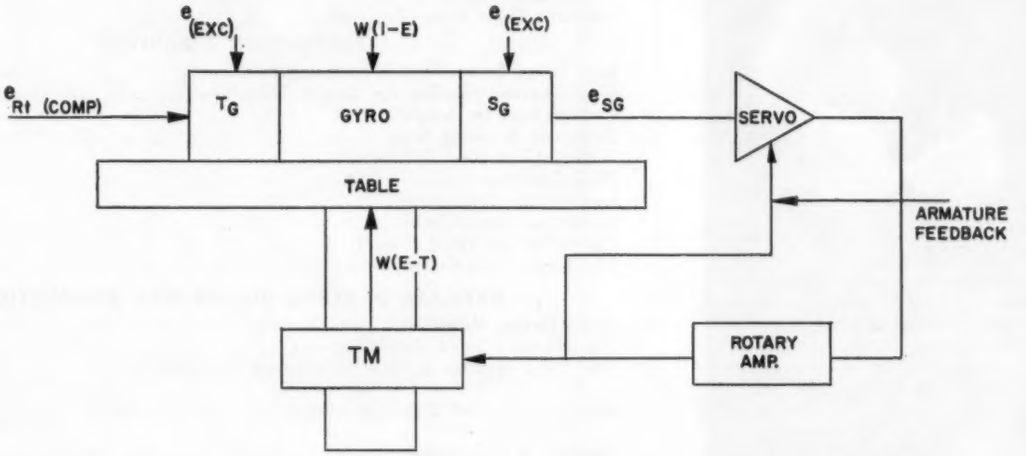
AIR BEARING RATE TABLE

by Goddard C. Parsons, John A. O'Shea and Frank H. McGeough

The prime measure of gyro quality is the residual drift of the instrument over specified limits of time. Minimizing this parameter by elimination of mechanical compliances in the test stand and electronic errors in a closed-loop servo system will provide a truer evaluation of gyro performance. The authors are design and test engineers in the Inertial Products Dept. of Dunn Engineering Corp., Cambridge, Mass.



$e_{Rt(comp)}$—Reaction torque comparison signal
S_G—Signal Generator
T_G—Torque Generator
e_{exc}—excitation current to torque and signal generators
W(I-E)—Angular velocity of earth with respect to inertial space
W(E-T)—Angular velocity of table with respect to earth.
e_{sg}—transducer error signal
TM—torque motor

FIGURE 1. GYROTEST Servo loop, Block Diagram.

INERTIAL GYROS are typically tested in the type of closed loop system shown in Fig. 1. The gyro is mounted on the table top and the signal generator microsyn or pickoff transducer electrical output is passed through the electronic system and back to the table. In this configuration the amount of table rotation should faithfully follow the amplitude and sign of the output signal of the gyro.

The biggest limiting factor in this test system is the friction inherent in the axis support bearing on the table. Unfortunately, this friction is not constant over the complete rotation (360°) of the conventional turntable. The test results then become random in nature and contribute to the uncertainties in testing and evaluation. To clarify this statement, the standard M.I.T. Type "D"[1] table produces frictional torque variations which introduce noise into the servo loop and create tracking errors which prevent the table from truly "following" the gyro. Needless to say, the test results always represent a composite of both gyro and table performance.

Recent gyro developments have made this problem critical. Gyro designers lately have succeeded in producing instruments with drift rates so low as to baffle conventional test tables. Inherent deficiences in mechanical bearings—in particular, the start-stop "stick slip" effect which is produced by static friction and which inevitably accompanies rotation of mechanical bearings at low rates—are responsible for this.

[1]The Type "D" table, designed and built about 10 years ago, employs conventional roller bearings.

In a closed-loop servo test set-up in which gyro performance exceeds table performance, the roles of test specimen and test equipment are reversed. The gyro evaluates the table—a ridiculous situation, but a painful episode in the experience of many inertial engineers.

The ideal solution to frictional torque variations is the use of gas or fluid bearings in the test table. In an initial attack on this problem, Dunn Engineering Corporation's Cambridge Engineering Laboratory developed a compensated fluid bearing and incorporated it in a large equatorial platform (Model T818) which was introduced commercially in 1957.

Oil Turntable Bearings

The pressurized oil bearings in this massive turntable made possible the achievement of frictionless rotation and precise orientations even with loads in excess of 500 pounds. All metal-to-metal contact in the bearing was eliminated.

The resulting accuracy of rotation was dependent only on the location of the mean surfaces. This was because the fluid bearing, or film, served to average the geometry of the bearing surfaces, resulting in precise location of its center of rotation.

With metal-to-metal contact gone, the main resistance to turning arises from viscous shearing of the fluid in the bearing gaps. When low viscosities and modest rotational speeds are employed, these shearing forces are low for the bearing sizes involved. They are, in addition, essentially constant at fixed speeds without exhibiting any of "stick slip" effect which is characteristic of even the best ball or roller bearings.

Non-uniform torques experienced in fluid bearings appear to be due in general to changing inertia or momentum forces in the fluid. They are much smaller, however, than the random torques found in mechanical bearings.

In current applications, oil bearing turntables are used principally with complete navigational systems to check alignment of their inertial components and to observe gyro and platform drift characteristics.

Air vs Oil Fluid Bearings

The development of the oil bearing did not end the harassment of the test engineer at the hands of ingenious gyro designers. A bearing fluid was therefore sought, and found, which exhibits sharply improved viscous characteristics over those found in oil. The new fluid is air.

Theoretical considerations pointed to air as the ideal bearing fluid even before a good air bearing was developed. For example:

1. Viscous drag torques would be much lower than for oil.

2. Torques arising from non-uniform inertia or momentum forces in the fluid would be at least an order of magnitude less than for oil.

3. There would be no problem of fluid recirculation. Air, exhausted into the atmosphere, would continuously purge the bearing system.

4. The dynamic characteristics of air are such that it is insensitive to variations in temperature. (Conversely, small variations in oil temperature may produce substantial random effects on bearing behavior, even in a capillary-compensated oil bearing design.)

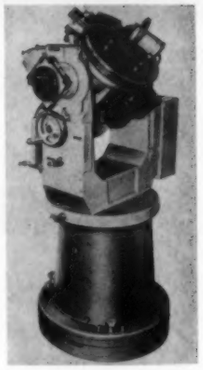


FIG. 2. AIR BEARING Servo/Rate Test Turntable, Dunn Model T900.

The use of air quickly resulted in the design and development of vastly improved turntables using gas-lubricated bearings. However, certain early gas bearing design approaches introduced new problems of instability.

Initial experiments with air bearings included the investigation of designs using small grooves or recesses which create constant-pressure pockets. These increase the load-carrying capacity of the bearing. Such bearings tended to self-oscillate, or flutter, except under certain restrictive conditions.

The so-called "air hammer" phenomenon found in this design is due to an inherent instability caused by the pockets. These self-oscillations were eliminated through design changes, but the bearings were still only marginally damped.

These problems led to experimentation with inherently compensated air bearings which avoided the use of recesses and were basically stable. Characteristics of the Dunn Model T900 Air Bearing Servo/Rate Turntable (Fig. 2) bear evidence that the design is well suited to turntable applications. It has high stiffness (on the order of 5×10^6 pounds per inch) and high relative stability; it is positively damped and not susceptible to the "air hammer" effect of earlier designs.

The new gas bearing resembles a conventional sleeve-type journal bearing with a thin film of air separating the fixed and rotating parts. The fluid volume is maintained by supplying air through upstream restrictions or orifices so spaced and of such size as to provide controlled flow to the bearing gap.

By using a film of air to separate the movable and fixed bearing surfaces, Dunn developers found that "stiction" is avoided and viscous drag is negligible. Gas flow through the bearing continuously purges the bearing surfaces and keeps them clean. The gas itself either may be air from an ordinary shop line (80-120 psi suitably decontaminated) or dry nitrogen from a high pressure compressed gas chamber.

What does this testing accuracy mean in terms of cost? About 25% more than for conventional test tables. However, the demands of inertial gyros now reaching the market—ultra accurate models with drift rates on the order of 0.001°/hour, a rate of approximately 1 revolution in 40 years—can be met only with fluid bearing tables likewise having accuracies of this order.

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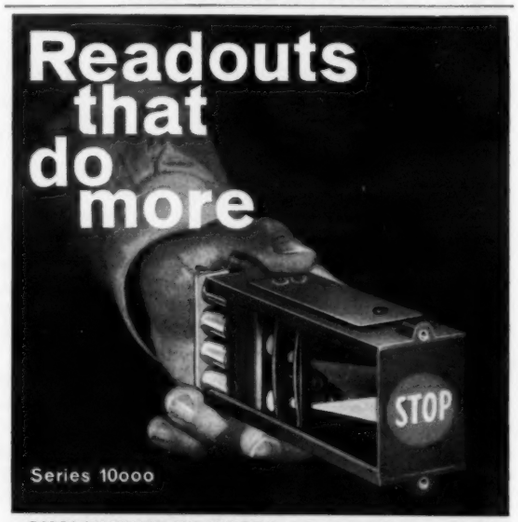

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FIG. 2. ROTOR ASSEMBLY, only moving part in this miniature Hall-effect synchro, consists of a magnet, a shaft and two bearings.

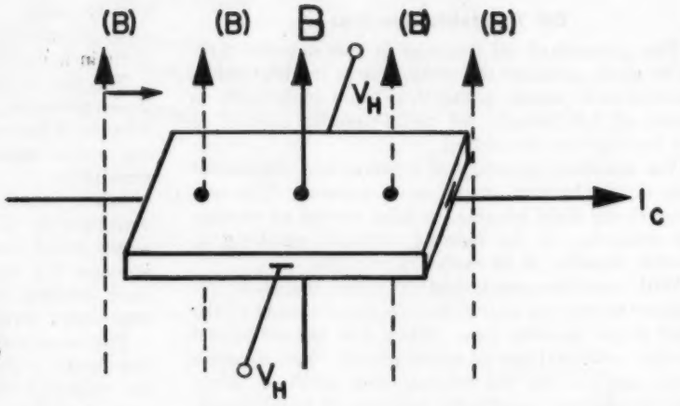

FIG. 1. HALL-EFFECT basic principle. Electromotive force is generated in suitable materials at right angles to magnetic field and control current.

RECENT ADVANCES made in Hall* effect materials and their manufacture have opened new fields of application, particularly in wirewound rotating components and other devices in which windings and sliding contacts can be replaced by varying magnetic fields without using physical contacts.

Wire-wound coils, embedded tightly in mechanical structures, and sliprings, brushes and commutators are parts which in great measure reduce the life and reliability of the components used in military systems.

There is a low physical limit to the size of magnet wire that can be efficiently used in miniaturized wirewound devices without degrading their reliability. Furthermore, production costs of wire-wound devices increase exponentially with miniaturization and high precision, making further progress slow and costly.

On the other hand, semiconductor materials are ideally suited, not only for miniaturization with considerable weight saving (e.g., the transistor), but also to extend the range of component applications to dc and high frequency ac without impairing their performance or introducing phase-shift problems. Direct current operation is of great importance when solar batteries or fuel cells are the power sources in systems, with the power supplied directly to the loads without conversion and associated losses.

The use of permanent magnets as field sources to control and operate Hall effect devices further simplifies the design. It is feasible to shape the magnetic field with respect to the associated semiconductor material in such a manner that a high sensitivity to motion or displacement, at high signal-to-noise ratio is obtained, making the assembly particularly useful in accelerometers, pickoffs, and other stable platform components, as well as in signal monitors, modulators, potentiometers, DC Motors, synchros, tachometers, and similar servocomponents.

*Principles of the Hall effect have been explained in many recent articles, including references 1 to 7 listed at the end of this article. All designs described herein are protected by patent applications filed or in preparation.

Windingless/Brushless Research Project

Some time ago, the Kearfott Division of General Precision, Inc. initiated a study and development of hardware for various solid-state devices with the object of replacing windings and wear-prone contacts by semiconductor materials. The company is also presently engaged in the development of Hall-effect synchros and resolvers, a program sponsored by the Navy Department, Bureau of Naval Weapons.

Various physical phenomena were investigated for use in the proposed solid-state devices, some of which are now in an advanced stage of development. Operating hardware has already been tested, with satisfactory results. For signal producing devices, the gauss effect (magneto-resistance effect) and Hall effect (galvanomagnetic effect) were investigated. With the objective of replacing the conventional commutators and brushes in dc motors, electrostatic and electromagnetic, as well as Hall-effect sensors, were considered.

For this reason the most promising devices incorporate Hall-effect materials with permanent magnets as the basis for their operation.

The Hall Generator

Hall generator subassembly may take various configurations, but in general it consists of:

- a crystal or thin-film, made of material exhibiting the Hall effect (Fig. 1),
- a heat sink plate, or backing plates,
- an envelope to protect the Hall material and to support backing plates, and to anchor the connecting leads, and
- flexible-lead terminals for input and output connections.

Presently available materials exhibiting Hall effects of usable magnitude are indium arsenide, indium antimonide, indium phosphide, indium arsenide phosphide, germanium, and silicon. Each material has its merits. In devices where temperature and magnetoresistance effects are of minor importance, and a comparatively high Hall-voltage output at low interval resistance is required, the indium compounds are used. For stable signal generation, with low temperature and other effects, germanium or silicon, properly doped, is the choice[12].

To obtain the required stability and optimum performance of Hall generators in the new devices, many technical problems must be solved. These are:

- the temperature effects upon output voltage and internal resistance,
- the magnetoresistance effect (change of resistance under influence of magnetic field),

Windingless Components

By Z. R. S. Ratajski
Kearfott Div., General Precision, Inc.

Research into the twin fields of higher reliability and component miniaturization has met with major problems in those components which use windings and sliding electrical contacts. As efforts to "improve while minifying" conventionally-designed components continue, research has turned toward the application of hitherto unused physical principles, using recently developed solid-state techniques. This article, by the Chief, Research and Advanced Development Department of the Kearfott's Precision Components Group, a leading manufacturer of conventional wire-wound components, illustrates the impact of this research on the present state of the art.

the strain effect upon characteristic parameters of the generator,

the noise level (output voltage at zero field) the linearity and symmetry of the output.

The optimum performance of a Hall generator also depends upon the size and configuration of the sensing Hall-effect material and the operating level of the magnetic field. To obtain high field levels in a design in question, the air gaps can be reduced by providing ferromagnetic backing plates in the Hall generators. The heat dissipation ability of the assembly can be increased by the addition of heat sinks inside or outside the Hall generator. In dc operation, hysteresis effects are present which can be reduced by using selected ferromagnetic materials with proper design of the return path at optimum magnetizing levels.

In many devices the noise level must be kept as low as possible. The major part of the noise voltage in normal operation is the "misalignment voltage" caused by the misalignment of the output contacts providing the terminal to the sensing Hall-effect material. This misalignment voltage can be reduced by a recently developed electrical alignment method[8]. Furthermore, to assure linearity and symmetry of the Hall voltage, the contacts between the terminals and the sensing Hall materials must be ohmic. Rectification, thermoelectric effects, and other undesirable phenomena at the points of contact should be avoided. To achieve this, various techniques have been developed and already described[9].

The Hall generator, when used with associated equipment, should be regarded as a four terminal resistance bridge. The input terminals are continuously connected to the output terminals through the sensing material. When used in series-connected pairs to double the output, the Hall generator resistances and their ratios should be identical within close limits at all operating conditions, a requirement difficult to meet in practice.

Most important, however, is the choice of the Hall material for the sensing element and its preparation and fabrication. New manufacturing techniques are being investigated and introduced to replace the etched crystals with thin-film elements[14]. Recent improvements in permanent magnets will allow increasing the magnetic field level, which will contribute to a better overall performance and higher efficiency.

Many problems and conflicting requirements must be taken into account before a Hall-generator is developed for a particular new device. To optimize Hall-generator characteristic parameters is not an easy task.

Windingless and Brushless Synchro-Resolvers

Present conventional synchros and resolvers consist of a wire-wound slotted stator and a wire-wound rotor with a slip-ring brush assembly in a common housing. In the windingless and brushless synchros, known as solid-state or Hall-effect synchros, the stator winding is replaced by a number of Hall-effect generators. A rotating permanent magnet, mounted on a shaft, takes the place of the wire-wound rotor. The Hall-effect synchro has, therefore, no moving parts other than the rotor asembly, consisting of a magnet, a shaft and two bearings (Fig. 2). The circuit for a Hall-effect synchro-resolver is compared with that of its wire-wound counterpart in Fig. 3. Several configurations of the stator assembly are possible using one or more Hall generators to obtain the desired performance. The same basic design may be used for synchro transmitters, synchro control transformers and synchro differentials.

One experimental synchro-resolver uses four Hall generators located in four slots in the magnetic return path (Fig. 4). At an angle $\theta = 0°$ (the synchro electrical zero), the magnetic flux crosses the two Hall generators associated with the output V_{H1} at its maximum, whereby no voltage appears at terminals V_{H2}, because the flux across the two other generators is zero. With increasing angle θ, both outputs than follow a sine or cosine function, as shown by the graph in Fig. 4, for a constant input current to the Hall generators. With proper design, an identical voltage output pattern of a conventional wire-wound resolver is obtained, except that the output voltage is lower and the two outputs are coupled resistively through the Hall generators.

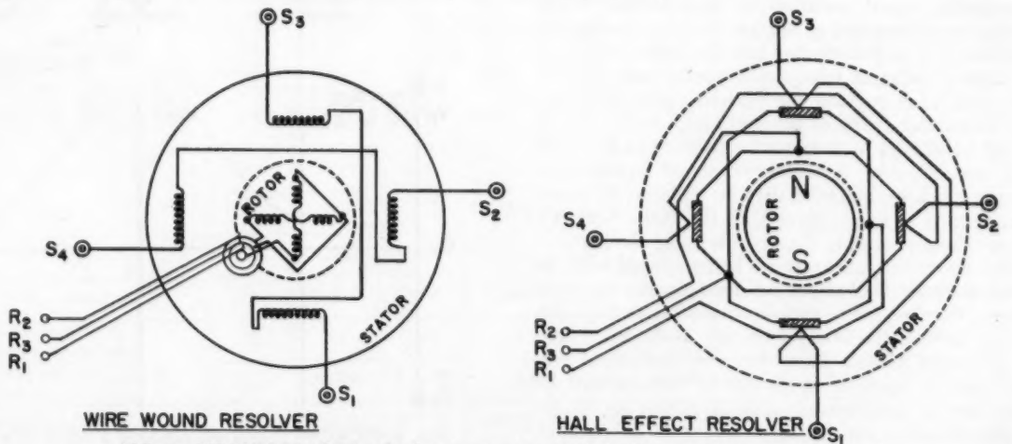

FIG. 3. CIRCUIT DIAGRAMS of wire-wound and Hall-effect resolvers are compared.

(Continued on next page)

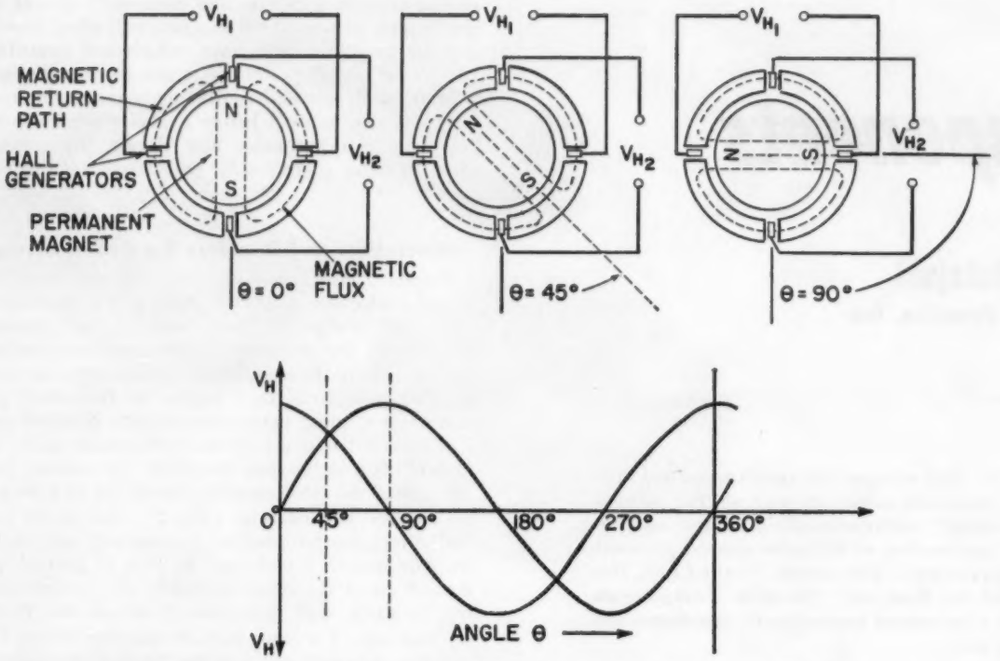

FIG. 4. EXPERIMENTAL synchro-resolver uses four Hall generators located in four slots in the magnetic return path.

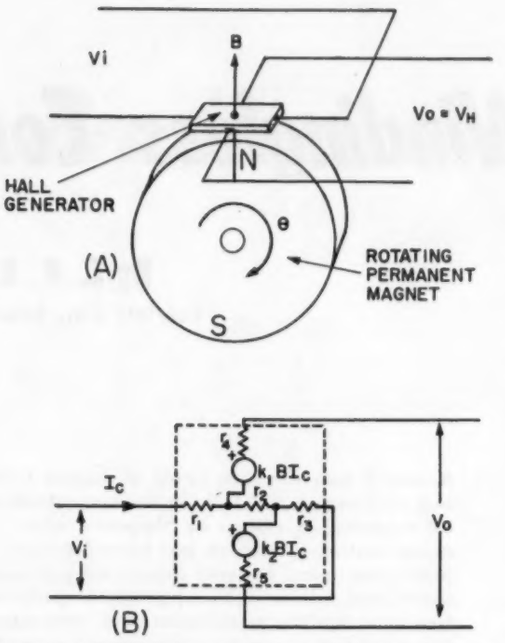

FIG. 5. HALL-EFFECT, brushless potentiometer, (a) basic principle. (b) equivalent circuit diagram of the Hall generator.

The output voltages of wire-wound synchros are ac, usually 400 cps or 60 cps. The Hall-effect synchros may operate either with dc or ac without any modifications being made to the circuits or design. With ac input to the Hall generators, the outputs are position-modulated ac. With dc input, the outputs are similarly modulated dc.

Present wire-wound synchros are used for a multitude of applications, e.g. in open-loop systems for indication purposes or for torque transmission (torque synchros); for error signal transmission in closed-loop servo-systems (control synchros); or as single components for signal modification, modulation, or generation in computers or similar devices (computing synchros). It is hoped that the Hall-effect synchros, all having the same basic design, with three variants only, will soon replace the various types of control and computing synchros presently required—with the added advantage of increased reliability in miniaturized frames—over a wider range of applications. Torque synchros, however, may be replaced by micro-miniaturized servo-packages with the Hall-effect control synchros providing the error-sensing elements.

New fields of application are being opened with the introduction of Hall-effect synchros. In the ac applications, the frequency may be extended to high frequency beyond the kilocycle range. Preliminary tests on prototype models show that the Hall-effect synchros can be operated up to 300 kc without any deterioration of performance and extension up to the megacycle range can be easily achieved if required. With dc operation, new system concepts are possible. Application notes with performance specifications are currently being prepared to serve as a guide to system designers.

Brushless Potentiometers and Pickoffs

The principle of stationary Hall-generators affected by a variable or transient magnetic field can be utilized in brushless potentiometers and pick-offs (Fig. 5). With the rotation of the permanent magnet over $\theta = 360$ angular degrees against the stationary Hall-generator, the magnetic flux varies from maximum to zero and reverses from zero to maximum, produc-

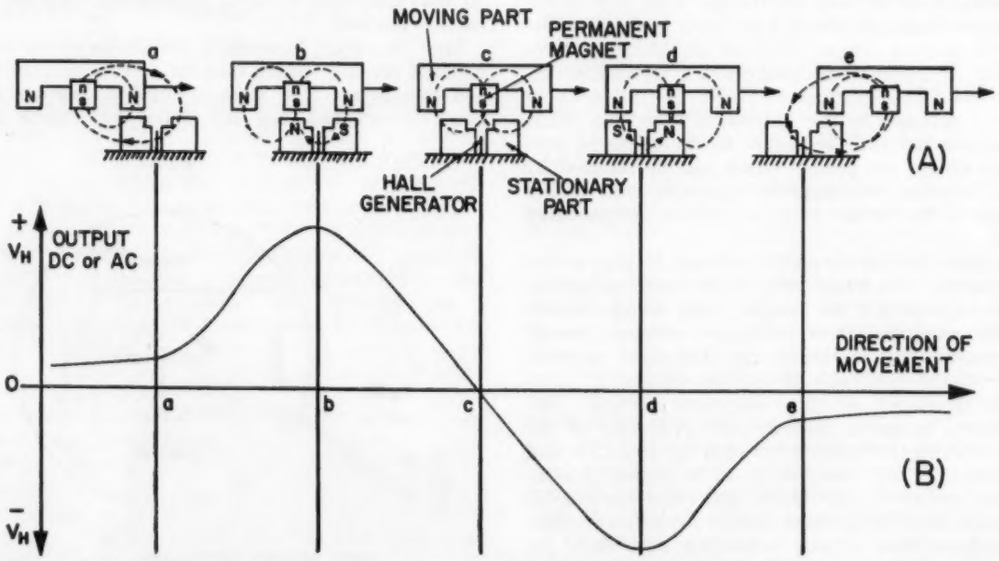

FIG. 6. PICKOFF shown will produce a signal at a predetermined position of a moving member, independent of its speed.

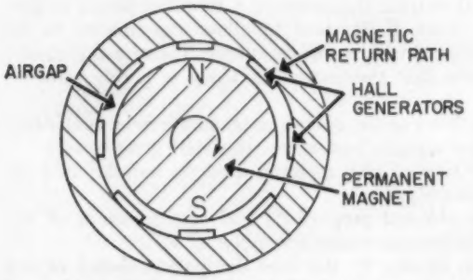

FIG. 7. HALL COMMUTATOR of brushless DC motor.

ing an output voltage V_o equal to the Hall voltage V_H of the Hall generator as a function of the angle θ. The input voltage V_i can be ac or dc. By shaping the stationary Hall generator or the rotating magnet, any relation between shaft displacement and output voltage can be obtained.

Pickoffs for rotational or rectilinear motion utilizing Hall-effect have the advantage over electromagnetic or other types that the output is independent of speed or rate of change of motion from standstill to a velocity over 300 ft/sec. An example of a pickoff that will produce a signal at a predetermined position of a member moving rectilinearly is shown in Fig. 6A. The moving E-shaped assembly carries a permanent magnet which produces the reversing flux across the Hall generator mounted in the stationary part of the pickoff. The direction of motion is from position (a) to position (e). The graph in Fig. 6B shows the output voltage obtained at the corresponding positions between (a) and (e). The position of peak output at (b) and (d) and the zero position at (c) is independent of the air gap between the pickoff parts. The signal thus obtained is independent not only of speed of motion, but also of vibration and other environmental conditions. Various forms of permanent magnets and associated magnetic structures can be used to obtain the required signal for a particular application.

Brushless potentiometers and Hall-effect pickoffs show considerable promise where low friction, low reaction torque, high reliability, high sensitivity, and stability of signal (to follow any desired function) is required.

Brushless D-C Motors

For several years, the development of reliable and small brushless dc motors, with true dc motor characteristics, has been a goal of many motor manufacturers. It is also a top requirement for military systems, where noiseless operation with long life is a necessity. A brushless dc motor is the drive most suitable for inertia wheel systems to control satellites in space since they are supplied directly from solar batteries[13].

Of various types of commutators considered during an initial study, the Hall-effect commutator displayed superior flexibility and simplicity.

The Hall commutator consists basically of a rotating permanent magnet (Fig. 7), which provides the field to affect the stationary Hall generators which are mounted around the magnet on a circular return path. There is an air gap between the magnet and

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Excitation 400 cycles	Fixed Phase	26v	26v	26v	115v	26v	26v	115v	115v	115v	115v
	Control Phase	33v	33v	33/16.5v	33/16.5v	33/16.5v	33/16.5v	40/20v	40/20v	40/20v	40/20v
Length, inches		0.865	1.565	0.840	1.165	1.332	1.350	1.340	1.915	2.049	2.552
No-load speed, RPM		10,000	10,000	6,000	6,000	5,000	6,000	6,000	5,300	6,000	5,900
Torque at stall, oz. in. (nominal)		0.1	0.1	0.22	0.33	0.22	0.22	0.6	0.6	0.6	0.6
Acceleration at stall, rad/sec^2		50,000	37,000	86,500	86,500	33,800	67,800	41,500	26,500	38,500	34,200
PRICE, single unit		$200.00	$300.00	$75.00	$80.00	$120.00	$125.00	$75.00	$125.00	$130.00	$135.00

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the surfaces of the Hall generators. With the magnet rotating, the Hall generators produce voltage transients, the amplitude of which are independent of speed. Furthermore, the transients occur in synchronism with the rotating magnet. The transients may also be used for sensing, triggering, driving, or biasing any associated electrical networks for larger power-handling capacity, linearization or other purpose.

Fig. 1 shows a conventional Hall generator. Assuming that the magnetic field B is moving along the axis of I_c, a Hall voltage transient will occur at terminals V_H. Let three such Hall generators be connected in series as shown in Fig. 8(A). With the field B moving along I_c from position B to B_3, voltage transients from V_{H1} to V_{H3} will appear in synchronism with the field movement. The same transients will be produced when the three Hall generators are combined into one strip, Fig. 8 (B). With a load, represented by a coil L, connected to the Hall terminals, currents will flow in the coils in sequence from L_1 to L_3.

The strip is now bent in a circular fashion to form a slotted ring around the magnet, Fig. 9. On both sides of the strip, 12 pairs of Hall terminals are provided. The strip is, therefore, equivalent to 12 Hall generators connected in series. With dc applied between terminals 1-2, a control current I_c will flow in each of the Hall generators, which are also subjected concurrently to varying levels of the magnetic field. With the magnet stationary, the Hall generators of the strip, located opposite the North pole and associated with loads L_6 and L_7, will produce a maximum positive Hall voltage; those opposite the South pole and associated with loads L_1 and L_{12}, will produce a maximum negative Hall voltage. Generators L_3, L_4, L_9 and L_{10} are located on the zero magnetic axis and will produce no output. With the magnet rotating, there will be 12 positive and 12 negative voltage transients produced for each revolution. Each load will be subjected, therefore, to ac in synchronism with the rotation.

In a dc motor with a Hall commutator, 12 stator coils are connected directly to the Hall terminals of the strip. If the stator coils are displaced by 90° with respect to the associated Hall terminals (with a two-pole rotor), a quadrature stator field is created which will interact with the permanent magnet field, thus providing motor action. The control current I_c to the Hall commutator is also the input current to the dc motor. The stator coils are isolated from each other to prevent any circulating currents and to assure the highest possible efficiency. The rotating stator field produced by the stator coils is instantly reversible because the polarity of the transients (and the stator coil currents) will change with the reversal of the dc input. The amplitude of the voltage transients (stator currents) varies linearly with the input voltage and is independent of the speed. One permanent magnet may provide both the motor and the Hall-commutator fields. Only two terminals for the motor input are necessary. All other connections between the stator coils and the Hall commutator are made within the stator. With small modifications to the Hall commutator, many variations are possible.

A breadboard model of a dc motor is shown in Fig. 10. Individual stator coils and Hall generators are connected outside the motor in a terminal board to provide check points and to allow experiments to be carried out with many variations. Tests on this model indicate that the motor efficiency is highly affected by:

- the level of the operating magnetic field in the motor air gap and across the Hall generators,
- the type of Hall material used, its mobility and resistivity,
- the physical proportions and configurations of the Hall-commutator assembly,
- and, finally, by the heat dissipation ability of the Hall generators and their mountings.

The power transfer efficiency of presently available Hall materials is still low. It is hoped, however, that with the progress being made in manufacturing techniques of Hall-generator thin-films, and in the magnetic materials of the ferrite family, practical prototype models of simple, rugged design will be available soon.

A breadboard of a satellite attitude control unit, in which a Hall-effect brushless dc motor is used to drive an inertia wheel, was also built and tested. The power-handling capacity of this unit was limited, however, by the available Hall generators. To satisfy an urgent need for such a control unit, the Hall generators were used as sensors, with their output controlling the dc power supplied to the stator coils of the motor. This arrangement produced a continuous motor action with a straight-line speed-torque characteristic of a conventional permanent magnet dc motor.

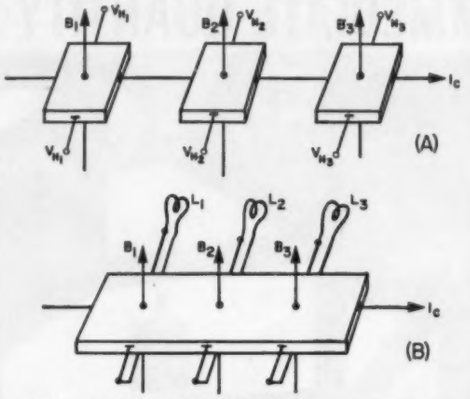

FIG. 8. HALL GENERATORS for commutator.

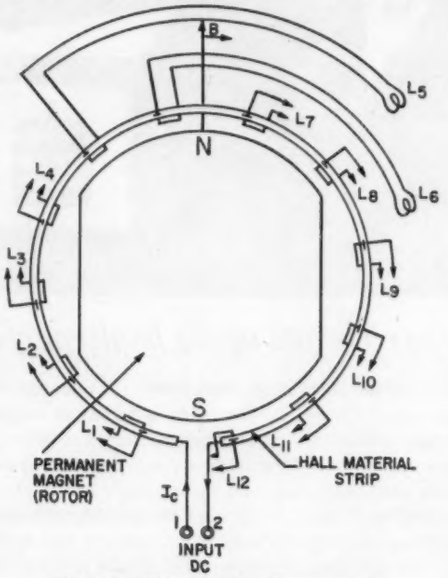

FIG. 9. LAYOUT of Hall commutator.

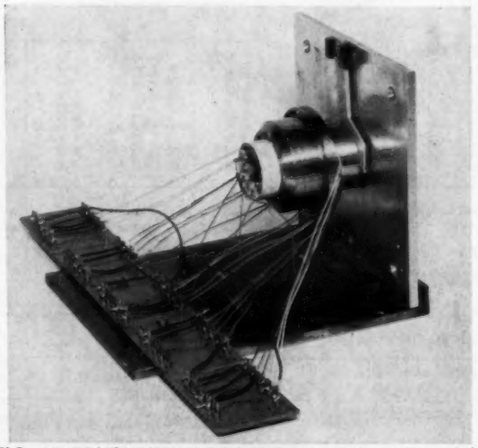

FIG. 10. BRUSHLESS DC MOTOR, breadboard model.

Frequency Resolvers

A new development is a frequency-modulated to frequency-modulated resolver, dubbed the "frequency resolver". Its frequency modulated input (f_i) is resolved into two frequency-modulated outputs (f_{o1} and f_{o2}) at a fixed carrier frequency (f_c), to follow the relationships:

$$f_{o1} = kf_i \sin \theta + f_c$$
$$f_{o2} = kf_i \cos \theta + f_c$$

where k is a constant depending on design parameters and θ the shaft displacement angle from reference zero.

The frequency resolver operates in a similar manner to a conventional synchro-resolver, which produces two amplitude-modulated outputs, i.e.:

$$V_{o1} = kV_i \sin \theta$$
$$V_{o2} = kV_i \cos \theta$$

Where V_i is input voltage at fixed frequency,
V_{o1} and V_{o2} are output voltages at the input frequency,
k is a constant and θ the shaft displacement angle.

Operation of the frequency resolver (Fig. 11) is accomplished by using appropriate electronic networks in conjunction with the Hall-effect resolver previously described. The frequency modulated input is converted to dc voltage by means of conventional electronic networks, which rectify the input to charge a capacitor. The dc voltage, so established, is amplified to provide the dc input current to the Hall generators of the resolver. The dc outputs of the Hall-effect resolver depend on the position of its rotor. The angle

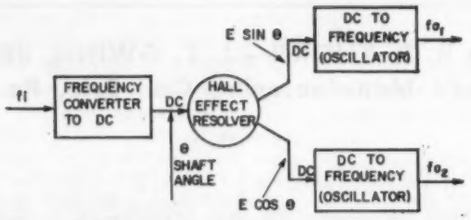

FIG. 11. FREQUENCY RESOLVER, block diagram.
fi input frequency
fo_1 fo_2 outputs
θ shaft displacement angle
E DC output of Hall-effect resolver, modulated by shaft angle θ

θ parameter is here introduced as the angle reference of the frequency resolver. The dc outputs of the Hall-effect resolver control two variable frequency oscillators, which can be of any type controllable by dc. In the breadboard, shown in Fig. 12, the electronic components are mounted around the Hall-effect resolver to form a package in a 1.750" dia housing, 2.200" long.

Development work is now in progress to reduce the number of electronic compounds in this unit by utilizing oscillatory phenomena recently observed in semiconductors. This will lead to a considerable reduction of size and improved reliability. The frequency resolver may replace complex electronic networks in Doppler radar systems, tracking systems or similar equipment, where frequency-modulated signals are used for computations or other functions.

Summary

The progress made in the past two years in semiconductor and magnetic materials and in their fabrication techniques has made feasible a number of brushless or windingless rotating components utilizing the Hall effect. The range of components is, however, not limited to those described here. The Hall effect and other physical pheonomena can be utilized not only in rotating components such as dc tachometers, servomotors, and torques, but also to static devices, in a accelerometers, function generators, signal-integrating modules and various transducers, for example. Some of the last-mentioned devices are already in an early development stage and show great promise because of their simplicity and amenability to extreme miniaturization.

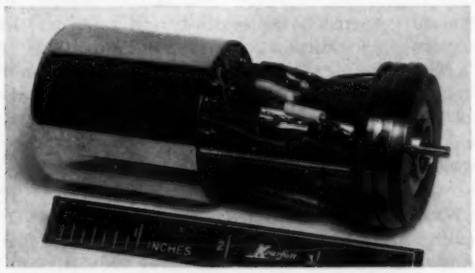

FIG. 12. COMPONENTS of breadboard frequency resolver are mounted around the Hall-effect resolver to form a package only 1.750" dia x 2.200" long.

1. W. J. GRUBBS, Hall-Effect Devices, Bell Sys. Tech. Joun., p. 853, May 1959.
2. R. KENT CROOKS, Hall and Magnetoresistance Effects and their Applications, Batelle Tech. Rev. p. 9, May 1960.
3. L. J. BRADY and B. A. MELEHY, Function Generators Using Hall Effect, Elec. Mfg., p. 62, August 1960.
4. J. R. McDERMOTT, Hall-Effect Devices: Steadily Growing Applications, Space/Aero, p. 145, May 1961.
5. J. W. MOTTO, Jr., Using the Hall Generator, A New Control and Instrumentation Component, Automatic Control: Part I, vol. 14, no. 6, p. 48, June 1961; Part II, vol. 14, no. 7, p. 24, July 1961.
6. S. P. DENKER, Properties of Hall-Effect Multipliers, Semiconductor Products, p. 32, June 1961.
7. E. H. PUTLEY, The Hall Effect and Related Phenomena, Butterworths, London, 1960.
8. C. WOOD, O. TISCHLER, and G. F. SCHROEDER, Reduction of Misalignment Voltage in Hall Crystals, Rev. Sc. Instr. 32, p. 209, February 1961.
9. S. HARAC and O. TISCHLER, Hall-Effect Generators for Solid-State Synchros and Resolvers, Electromechanical Design, p. 14, January 1961.
10. T. E. MOUNT, Thin-Film Hall Device is nearing Production, Electronic Design, p. 6, August 2, 1961.
11. S. HARAC, Measuring Function Accuracy of Hall-Effect Generators, Electro-Technology, vol. 68, no. 3, p. 134, Sept. 1961.
12. Z. R. S. RATAJSKI, Designing Solid-State Synchros with Hall-Effect Components, Electronics, 34, p. 59, Sept. 8, 1961.
13. J. J. ADAMS and R. G. CHILTON, Attitude controls for SATELLITES, A Weight Comparison of Several, NASA Memorandum 12-30-58L, Langley Research Center, February 1959.
14. R. F. POTTER, Evaporated Semiconductor Layer Program, NOL Technical Memo 43-5, Naval Ordnance Laboratory, Corona, California, 5 June 1961.

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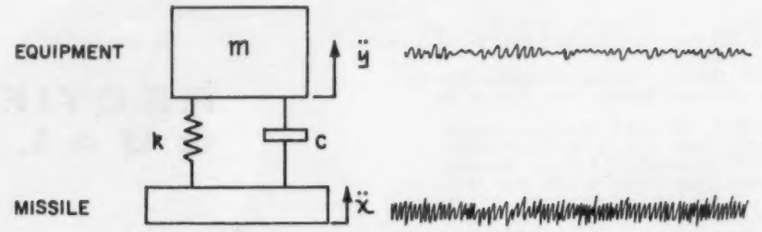


FIG. 1. ATTENUATION of random excitation by elastomeric suspension. As shown, the suspended unit feels only a varying amplitude, narrow band of frequencies near the resonant frequency of the isolators.

by R. P. THORN—J. T. GWINN, JR.
Lord Manufacturing Co., Erie, Pa.

The Authors

Dick Thorn (M.S. in E.E., Carnegie Tech '53) and Jim Gwinn (B.S. in M.E., Case Institute '57) are both well-qualified authorities on the analysis and design of vibration control systems. Both have been active in programs which resulted in protective suspensions used on Atlas, Titan, Poraris, Hawk, ground support equipment, shipboard and other weapons systems.

In addition to regular work activities, both have taught in-company courses in advanced mathematics and dynamic system analysis for their fellow engineers at the Lord Mfg. Co. Both are recognized authors, contributing regularly to trade journals.

Engineered Protection for Inertial Guidance Systems

ON-TARGET navigation of an ICBM is primarily dependent on the accuracy of its inertial guidance system. Such guidance systems, whether engineered as gimballed stable platforms or as "strapdown systems", are mechanical combinations of accelerometers and gyros. Although simple in concept, they are triumphs of mechanical precision, produced under ultra-clean environmental conditions and capable of achieving near-perfect accuracy.

The accuracy of either type of guidance system depends on (1) constant alignment of the instrument package with the axes of the vehicle; and (2) proper functioning of the guidance system despite environmental disturbances.

Guidance systems, being mechanical elements, have natural frequency and response characteristics which are functions of mass, spring rate and degree of damping for the distributed system. Each system consequently requires a dynamic protection system engineered to minimize unwanted responses produced by vibrations, shock and noise. Generally, low-frequency suspensions are required for stabilized platforms, while high-frequency suspensions are used for strapdown or body-mounted systems.

Nature of Missile Disturbances

Originally, dynamic environment specifications for missiles covered only sinusoidal vibratory disturbances and sustained accelerations. However, data from early liquid-fuel missile flights revealed that *random* acoustical disturbances are more characteristic of these engines. In solid fuel engines, the resonant burning of the fuel is an additional acoustical disturbance. This is a discrete sinusoidal frequency superimposed on the random excitations.

For most test purposes, the random disturbances may be replaced by a sinusoidal disturbance having the capability of duplicating the damage caused by the actual disturbance. Superimposed sustained accelerations up to 25 G must also be considered.

Hard vs Soft Mountings

With hard mounting, the guidance system is rigidly attached to the supporting structure. This usually requires that the guidance device be ruggedized and made less responsive. Ruggedizing commonly results in a significant weight increase and in degradation of vehicle performance.

Modification of guidance system response characteristics to move them out of the excitation region has been proposed. However, it is difficult to build any mechanical structure with all normal modes over 500 cps, and missile excitations often extend as high as 5000 cps.

Soft mounting, using flexible suspension of the unit, avoids degradation of performance while solving the protection problem. Such systems, using elastomeric mountings, have proved successful on operational Atlas and Titan ICBM's, Polaris IRBM's, unmanned drones and high-performance manned aircraft.

Elastomeric Suspension Characteristics

Elastomeric materials, combining damping and elasticity in a single package, are ideal for soft mounting applications because they provide more energy storage per unit volume than classical mechanical spring and damper combinations.

The problem of high-frequency response is particularly acute in such components as gimbal rings, gyro rotors and bearings, and accelerometers. Elastomeric suspensions successfully minimize the high-frequency excitation reaching these components (Fig. 1). For example, the original hard mounting configuration for the Titan three-axis reference system did not prove feasible because of the system's sensitivity. A three-point elastomeric system now provides the needed attenuation to protect the platform during the power phase of flight and to meet qualification tests.

Elastomeric suspensions generally result in weight savings compared to the weight penalty of ruggedizing. A suspension system weighing only 10% of the supported weight is considered exceptionally good. However, with elastomeric mounting the suspension system for the Atlas inertial platform weighs considerably less than this amount.

Suspension System Dynamics

Highly damped elastomeric mountings can be designed to provide almost any combination of stiffness or frequency characteristics. This is most important if different frequency characteristics in the transla-

tional and rotational directions are required. To use a resilient suspension most efficiently, recognized specialists should be consulted at an early design stage to assure adequate space envelopes and to prevent later compromise of performance characteristics in altering natural system frequencies.

A suspension system which is optimized for weight, cost and isolation frequency is a center-of-gravity suspension with mountings located on a plane through the CG of the mounted unit (Fig. 2.). This provides the most effective method for independent control of all natural frequencies and decoupled system response.

However, guidance equipment is frequently designed for hard mounting with its supporting structure located at the base of the unit. If the suspension system must be located beneath the supported unit, or unusual structural complications prevent adequate space allowances, a virtual CG suspension, or "focalization", may be employed (Fig. 3). This is accomplished by selecting specific combinations of (1) mounting stiffness, (2) the direction in which these stiffnesses act, and (3) location of CG with respect to the mounting plane. For translational inputs to the system in any direction, only translational response of the mounted unit will occur; i.e., the translational and rotational modes are decoupled.

Many types of elastomeric mounting configurations are useable in focalized suspension arrangements where base mounting must be employed. In such systems the use of highly damped elastomers offers the optimum balance of features.

Angular Response Problem

Conventional base type suspensions—mountings of nearly equal axial and radial stiffness located beneath the supported unit and in a common plane below the CG—are generally unsuitable for inertial guidance system protection. Such an arrangement results in rotational, or coupled, responses of the unit for translational inputs in any but the vertical direction (Fig. 4.)

Also, orientation of the mounted assembly in any position other than the normal attitude will result in a *static* rotational displacement of the unit with respect to the supporting structure, due to the weight vector. Such angular offsets create gyro error.

Angular response to translation inputs is a function of the location of the suspension-system elastic center and the center of gravity of the mounted unit. For externally motion-excited systems, typical of inertial navigation applications, the resultant excitation force acts through the system elastic center. If the center of gravity is located at some finite distance from, and not in line with, the resultant elastic force; a moment will act on the mounted unit to produce a rotational motion of the unit about the principal coordinate axis of the body . . . a mode particularly objectionable in these applications. The following assumptions simplify the analysis of the problem:

1. The offset of the CG with respect to the elastic center (a) lies in a plane which contains all the applied forces and reactions.

2. The resilient supports are linear and the effect

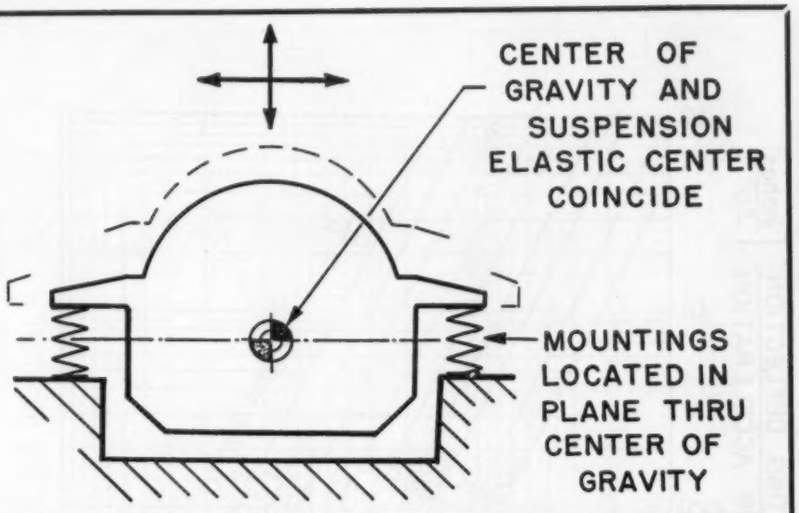


FIG. 2. CENTER-OF-GRAVITY Type of suspension.

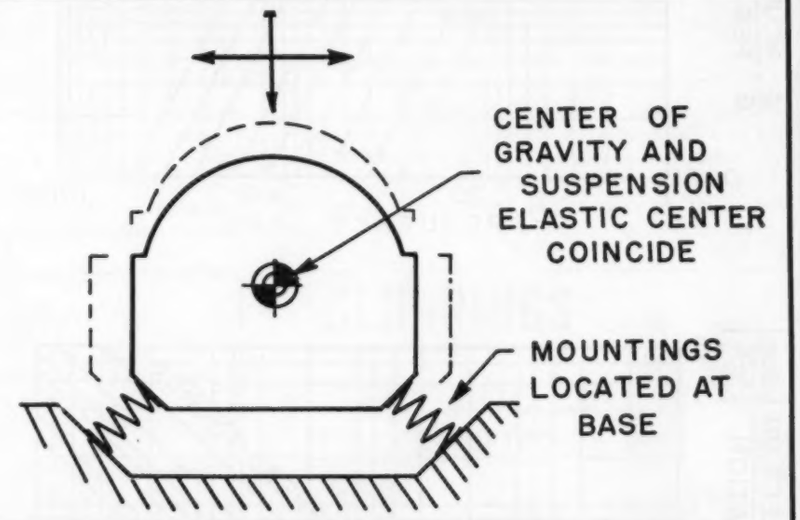


FIG. 3. FOCALIZED BASE type suspension.

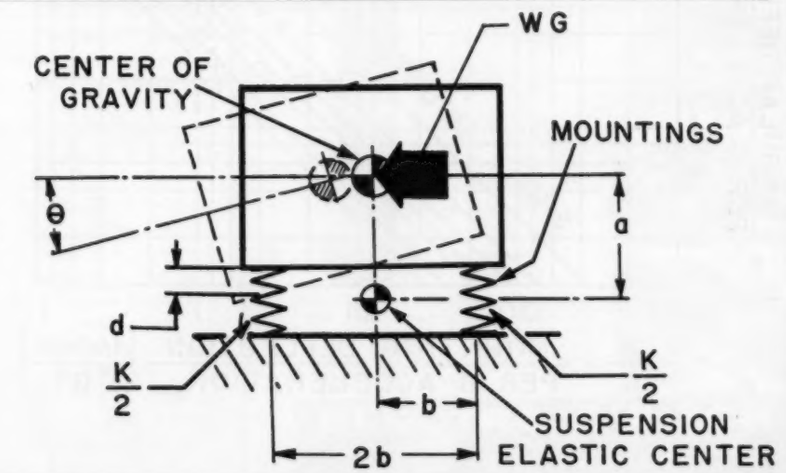


FIG. 4. CONVENTIONAL BASE-TYPE Suspension, including notations for equations (7) and (8), see text.

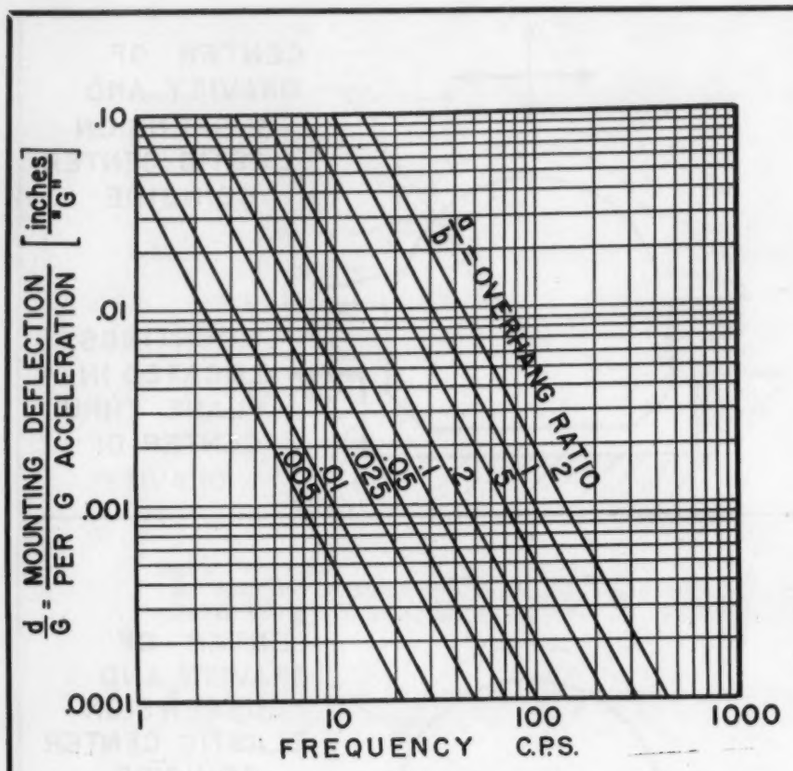


FIG. 5. ANGULAR DEFLECTION vs MOUNTING DEFLECTION for various half-mounting spreads.

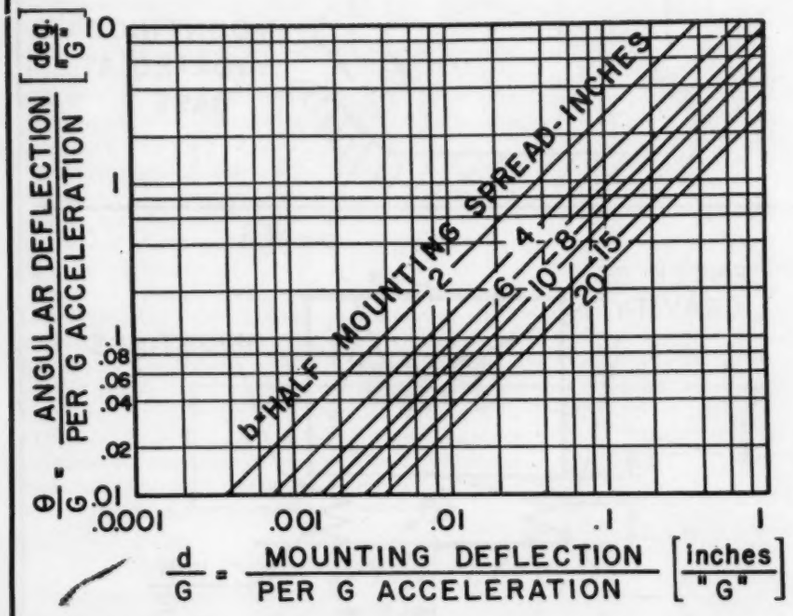


FIG. 6. DEFLECTION G vs. FREQUENCY for various overhang ratios.

of damping on the system mechanics is negligible.

3. Rotational responses occur about an axis through the elastic center and normal to the reference plane.

Fig. 4 shows schematically the system under consideration. For a force, WG, at the center of gravity there exists a moment, WGa, on the system which rotates the body about an axis normal to the reference plane and through the elastic center. As a result, the mountings deflect a distance d until moment WGa is balanced. The equation of equilibrium is

$$WGa = K_R\theta \quad (1)$$

The rotational stiffness K_R may be defined as

$$K_R = Kb^2 \quad (2)$$

and the angular deflection θ may be expressed as

$$\theta \approx d/b \text{ for small } \theta) \quad (3)$$

Substituting (2) and (3) into (1)

$$WGa = Kbd \quad (4)$$

Solving for the deflection of the mounting per G acceleration,

$$d/G = (a/b)(m/K)g \quad (5)$$

where quantity a/b is the overhang.
From linear-vibration theory,

$$f_n = \frac{1}{2\pi}\sqrt{K/m} \quad (6)$$

Solving this expression for m/K and substituting in (5) yields

$$d/G = (g/4\pi^2)(1/f_n^2)(a/b) \quad (7)$$

Equation (7) shows the relationship between the suspension natural frequency and overhang, and the resultant deflection per G of input that occurs in a coupled system. Typical values of each parameter are plotted in Fig. 5, for this relationship. It should be noted that this analysis would also apply to a system where the offset of CG and elastic center is lateral instead of vertical and WG acts in the vertical direction.

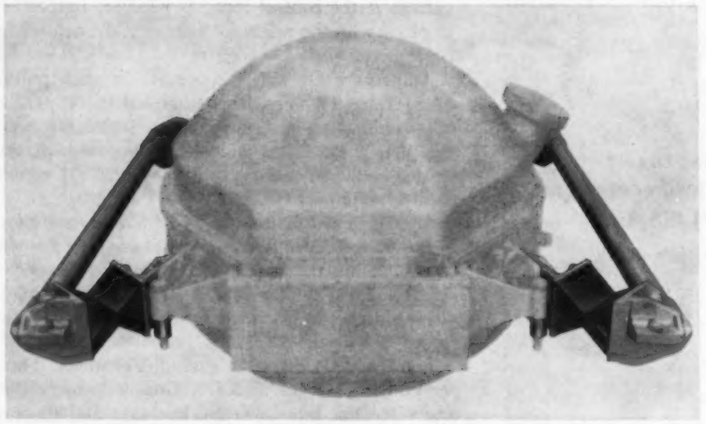
For inertial guidance system applications the angular deflection is of even greater interest since angular reference error particularly is to be avoided. This may be expressed as θ/G and is derived from definition of angle θ:

$$\theta/G = (1/b)(d/G) \quad (8)$$

Fig. 5 and 6 are useful in determining the maximum overhang a system can have if the desired natural frequency and tolerable angular offset the systems can have for a specified input are known.

Experience Important in Systems Design

Present levels of elastomer technology enable skilled compounders to match elastomeric units to a specified stiffness for sound, engineered inertial navigator protection. With predictable response charac-



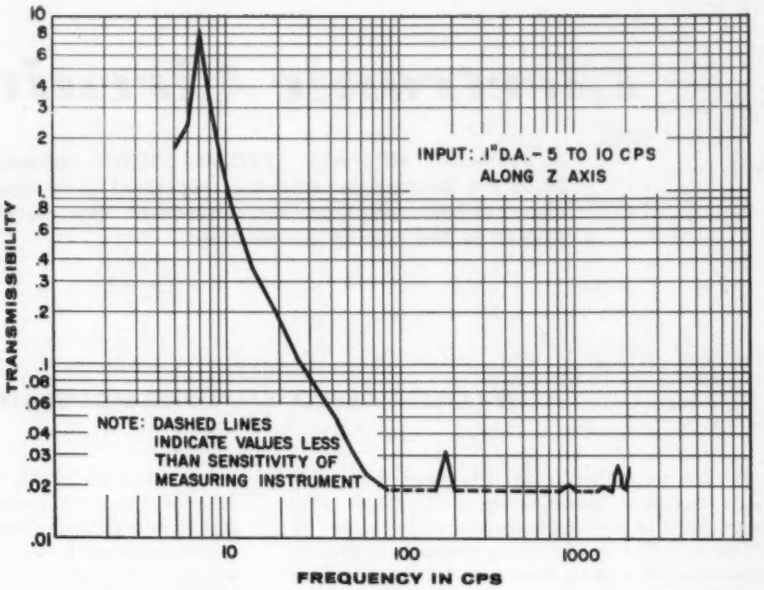
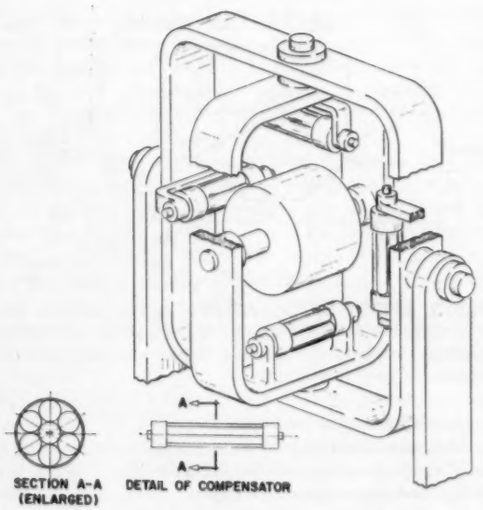


FIG. 7. FOUR X-SHAPED Isolators give C-G support to Atlas ICBM all-inertial guidance platform by ARMA. Transmissibility of 6.5 to 8.5:1 with natural frequency of 7 to 9 cps and high attenuation at 120 cps, natural frequency of the accelerometer, is shown in curve at right.

teristics in the elastomeric mountings and careful stiffness matching of mountings, the elastomeric center of focalized and center-of-gravity suspensions can be accurately located, with respect to the CG, to provide angular accuracies compatible with most system requirements.

Successful protective suspension design is based on known or predictable vibration tolerance of the guidance system. This results from extensive equipment testing or from prior experience and thorough knowledge of both custom elastomer compounding and complex excitation control. Successful suspensions result when the vibration control specialist knows what is involved—in terms of missiles in general, in inertial guidance systems in particular—and can work closely with design engineers responsible for producing the required performance in the overall system.

Gyroscopes Balanced Electrolytically



GYRO with two degrees of freedom is shown with Avcon Balance Compensators installed. Device adapts to any type gyro.

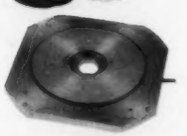
A novel device to keep gyroscope gimbals in perfect balance by inducing precisely the right amount of compensating torque utilizes the principle of electrolytic transfer of metal through a liquid.

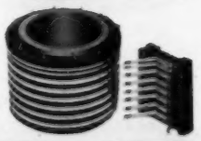
This device, a development of the Avcon Corporation, Scarsdale, N. Y., functions as an electrolytic cell with two equal masses of metal aligned at opposite ends of a small glass cylinder filled with a suitable electrolyte. Constant or pulsed dc of any waveform passed through the tube will plate molecules of metal from one end of the cylinder to the other. The direction of the plating and resulting mass shift will depend on the polarity of the current. As the relative masses of the electrodes change, compensating torque is induced and the gyroscope is brought back into balance.

The conventional method for balancing out gyros is expensive, involving delicate trimming of completed assemblies. Also minute movements of the ball retainers or shifts of balls in the bearing raceway can cause mass shift in a correctly balanced gyro. The new method provides a much less expensive method of mass trimming and one which can be used to correct drift even while the gyro is in use or after a long period of storage. Thus mass shift in a Polaris Type missile which might make its flight inaccurate could be corrected just prior to firing without any long and costly delay.

CIRCLE 92 ON READER-SERVICE CARD

SLIP-RINGS
and
ROTARY SWITCHING
ASSEMBLIES





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Electronic Circuity

A continuous MILITARY SYSTEMS DESIGN feature, these circuit ideas are selected because they represent good design. Significant characteristics which are not self-evident from the diagram are explained in the printed commentary.

LOW-POWER SERVO AMPLIFIER-MODULATOR

The servo amplifier in Fig. 1 is designed to supply 110 v rms to a Norden-Ketay size-15 60-cps servo motor. Used to correct the frequency of a master oscillator in a VLF synchronizing system, a 2v peak-to-peak output of a phase detector is fed through a low pass filter to the modulator input. The modulator is a balanced type with two adjusting potentiometers, used to minimize 60 cps in the amplifier output when the dc input is shorted.

Referring to Fig. 2, current is assumed to flow only in the direction of the diode arrows from positive toward negative polarity. Thus when the input is shorted to ground (zero input), current flows through the *upper* branch from q to r to p during an alternation when q is positive. During the next alternation when q is negative, current flows through the *lower* branch from p to s to q. Since matched diode pairs are used in the bridge, and also because potentiometers at r and s can be adjusted precisely, r and s are at zero potential.

When a small positive potential with respect to ground is put on the input lead, points r and s try to come to this potential. During the alternation when q is positive, the resistance of the upper branch $p\ r\ q$ is so low that the input voltage is reduced to near zero at point r; the 47 K resistor minimizes loading of the input terminal. During this same alternation, the lower branch resistance ($p\ s\ q$) is high and allows the input voltage to be connected to Q2 through the 47 K resistor and C3, resulting in a positive pulse with amplitude almost equal to the input voltage and duration equal to that of one-half cycle of the reference voltage being applied to Q2. The next alternation reverses the conditions and applies a positive pulse to Q1. The modulator may be viewed as a switch which alternately shorts first the input of Q1 and then the input of Q2 resulting in a series of pulses, having the polarity and amplitude of the input signal, being applied alternately to Q1 and Q2, in phase with the reference voltage. If the input potential is raised to a value exceeding the peak voltage at p or q, the normally back-biased diodes will conduct, limiting the voltage input to Q1 and Q2 to the peak voltage from one-half the secondary of T1. In the circuit herein described, this voltage is 2.8 volts (2 volts rms).

In brief, the action of the modulator is to provide a 60 cps output which has an amplitude proportional to the input control voltage, in phase with the reference voltage if the control input is positive, but 180° out of phase with the reference voltage if the control input is negative.

Transistors Q1 and Q2 operate in push pull into transformer T2 (Fig. 01), in which the 80,000 ohm CT winding normally used as a secondary is connected to the emitters and the 15,000 ohm "primary" is used as the secondary, to drive the 2N331 common-emitter amplifier, Q3.

Transistor Q3 is used to provide low-pass filtering of the 60 cps pulse train and to phase-shift the signal 90° to obtain the required relation of reference and signal voltages for the servo motor. This filtering and phase shifting is provided by the capacitor feedback from Q3 collector to base.

Transistor Q4 drives two parallel channels. The upper consists of Q5 and Q7, two common collector stages feeding into the capacitor C8; and the lower channel consisting of Q6 and Q7, two common emitter stages which drive C8 in parallel with the upper transistor train, Q5 and Q7. Transistors Q7 and Q8 are thus connected in series across the dc supply, but their outputs are in phase as shown by the arrows in Fig. 00. This arrangement provides better linearity over a greater voltage range than could be delivered by a single low-power transistor. The output transformer T3 has a 4000 ohm: 14,000 ohm ratio, delivering a maximum output amplitude of 110 v to the servo motor control field. The fixed field winding of the servo motor is supplied from the reference voltage of 80 volts to minimize heating and result in a no-load speed of 2400 rpm. The bias adjusting resistor R25 equalizes output voltages across Q7 and Q8, and negative feedback is supplied to the input of Q4 through the R22-C7 network.

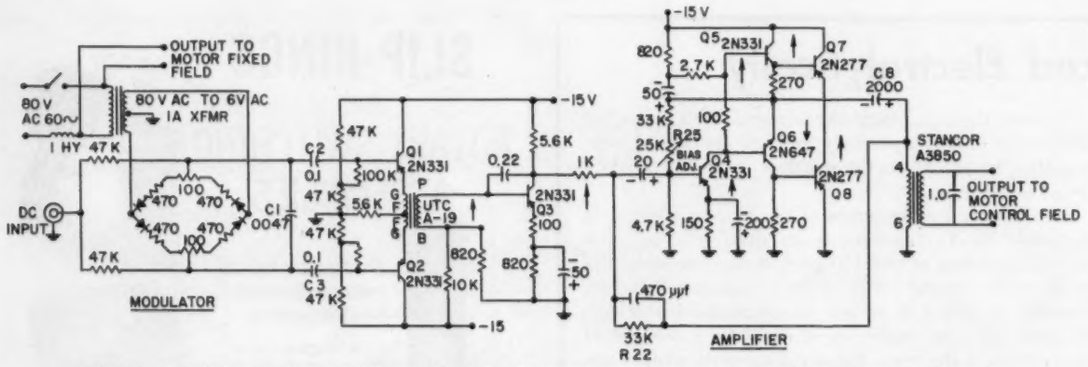


FIG. 1. SERVO Amplifier-modulator circuit is designed to drive a size-15 60-cps servo motor to correct frequency in a VLF synchronizing system.

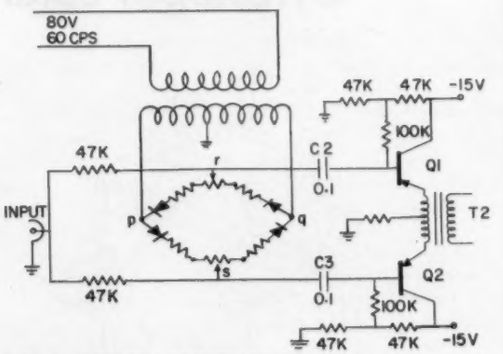


FIG. 2. BRIDGE MODULATOR circuit provides a 60-cps output with amplitude proportional to dc control voltage; in-phase for positive inputs and 180° out-of phase for negative inputs.

Amplifier supply voltage: 15 v.
Max. surge current: 1.5 amp
Normal operating current: 0.2 amp
No-load motor speed: 2400 rpm
Input: 0.5 v dc (maximum) for 100v rms to motor

Source: Mr. Chesley H. Looney, Jr., Goddard Space Flight Center, Greenbelt, Md. Also *NASA Technical Note D-669*, National Aeronautics and Space Administration, February 1961.

ELECTROMETER-AMPLIFIER FOR QUARTZ TRANSDUCERS

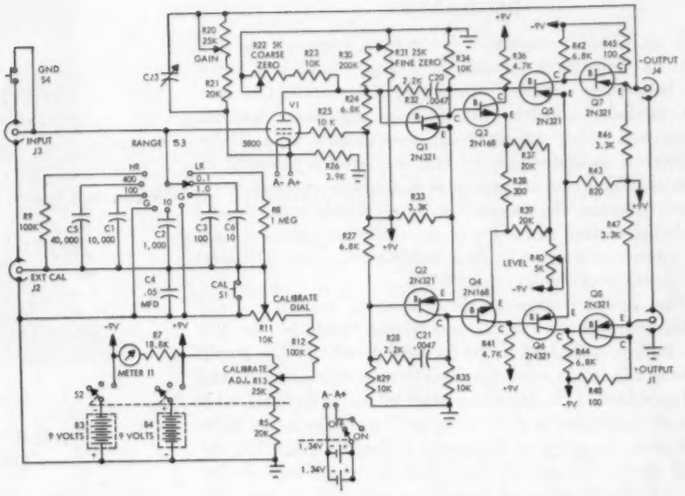
The accompanying hybrid circuit is intended to provide amplification of the output of a natural quartz piezoelectric pressure transducer having a maximum output voltage of 1 v. The output is adequate to drive all commercial oscilloscopes or amplifying-recording systems, including low impedance galvanometers. The balanced push-pull output supplies up to two milliamperes current into an output impedance of 100 ohms. Pushpull output is 12v (6v to ground).

The plug-in transistor amplifier is direct-coupled to the electrometer tube, which is a Victoreen 5800 or equivalent. This tube is supplied sealed in its housing as the 651-11 Electrometer Tube and Housing Assembly. The meter supplies ON-OFF and battery condition indications. If it records less than 1.0 ma all batteries should be replaced.

The circuit provides a method to apply a known calibration signal for oscilloscope comparison with the input signal. Accuracy of the calibration signal, adjusted by screwdriver control R13, can be checked by means of a precision voltmeter connected to the EXT CAL jack. Feedback adjustment through R20 varies the gain from 3:1 to 6:1. Fine and coarse zero adjustments which balance the circuit so that zero outputs result from zero input signals are provided in R31 and R22. The LEVEL Control adjustment reduces the potential from the + output terminal to ground to zero, so that the LEVEL and ZERO Controls interact on each other and must be simultaneously adjusted.

OPERATING PARAMETERS

Input voltage, max 1.0 v.
Input impedance, 10^{14} ohms.
Frequency range (3 db) 0-160 kc. Linearity 1%.
Output voltage, max 12 v p-p.
Output current, max 2.0 ma.
Output Impedance, 100 ohms.
Voltage gain 3-6.



Variable capacitor C23 is the high frequency compensating capacitor and its setting need not be changed unless the electrometer tube or plug-in amplifier is changed. It may then be adjusted by connecting a square-wave source to the input, and adjusting C23 for minimum distortion of the signal as observed on an oscilloscope.

Source: *Operating and Servicing Instructions Model 655 Amplifier-Calibrator, for Quartz Crystal Pick-ups, Kistler Instrument Corp., 15 Webster St., No. Tonawanda, N. Y.*

PARTICLE COUNTER AMPLIFIER

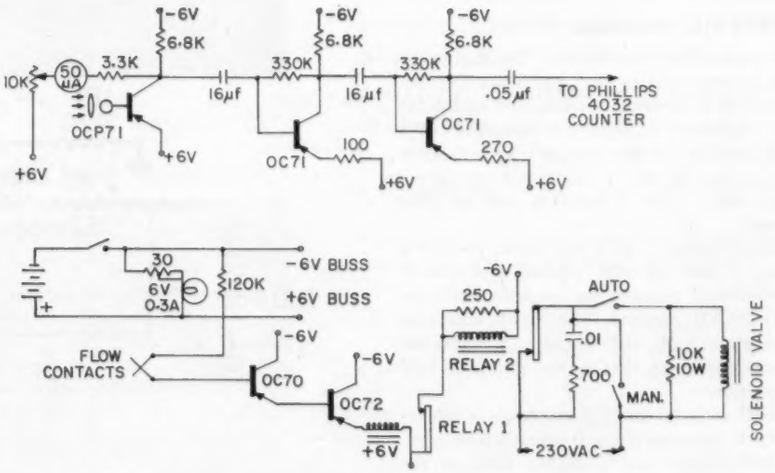
Photoelectric detection and counting of opaque particles of from 70 to 500 microns in length which are suspended in a low-viscosity liquid passing through a 500 μ diameter, glass capillary tube, is accomplished by the use of equipment using the circuit shown, together with a low-power microscope.

Macerated apple cells were counted in a study of fruit growth in the original application. Dispersed in a solution of distilled water, the cells are syphoned from a beaker through the capillary. When the level of solution in the breaker drops below the electrical contacts, K, relay 1 releases, and the NO contacts interrupt current to the power relay 2 which closes the solenoid valve, stopping the flow. The beaker is then rinsed with distilled water and a second counting run is averaged with the first.

Potentiometer P1 is used to adjust the meter current to zero when the light is blocked off between the capillary tube and the microscope by a shutter. When the tube is filled with distilled water and the shutter removed, the "intensity control" P2, is used to set the meter to a predetermined value.

When the suspension of cells is added to the beaker the counting cycle is started by closing the switch marked "auto", which opens the solenoid valve applying suction to the capillary. Pulses of approximately 0.5 msec are formed by the phototransistor as the cells intercept the light beam. The amplified pulses are fed directly to a Philips type 4032 counter. Source article discusses reduction of errors and calibration of the device. Equivalent transistors are available from AmpereX Electronic Corp., Hicksville, N. Y.

Power: 230 v ac, 6 v dc.



Source: Article by J. B. Cornwell, Auckland Industrial Development Labs., D. S. I. R., P. O. Box 2225, Auckland, C. I. New Zealand, and Dr. R. M. Davison, Fruit Research Div., D. S. I. R., New Zealand, in the Nov. 1960 *Journal of Scientific Instruments*, 1 Lowther Gardens, Prince Consort Rd., London, S. W. 7, England.

VOLTAGE-CONTROLLED TELEMETRY OSCILLATOR

A unit audio oscillator for transmission of physical data by converting variable dc voltage inputs into variable frequency outputs is shown in the circuit. Designed for modular construction, it uses miniature vacuum tubes and other conventional components in a Miller transitron oscillator circuit. The oscillator is preceded by a dc amplifier and its output is isolated from other oscillators and the vhf transmitter by a cathode follower and an LC pi-section filter. Up to six oscillator units are used simultaneously to modulate a single transmitter. The total frequency error is less than 0.3%.

The anode voltage of the transitron oscillator (V2) is limited between the 35- and 60-volt levels by two silicon diodes, both used in the forward direction. The amplitude of the anode sawtooth waveform is thus constant and independent of the characteristics of the individual tube. The flyback time is short compared with the sweep time, and since the slope of the sweep is linearly related to the grid return voltage of the oscillator, the frequency of the waveform obtained is also proportional to this voltage.

The transitron grid is returned to the anode of a single-stage dc amplifier at a level of 60 to 80 volts, and the data signals are applied to the grid of this amplifier, C1A. Manual control of each oscillator frequency is accomplished by varying the grid return resistance (RV2) of the transitron.

Component values common to all oscillators are given in Table 1 while frequency-dependent component values of capacitors and inductors are given in Table 2. All resistors are ⅛ watt capacity; the 1% tolerance resistors being of the high-stability carbon film type. Values for capacitors C1 and C2 at center frequencies given in Table 2 were experimentally determined.

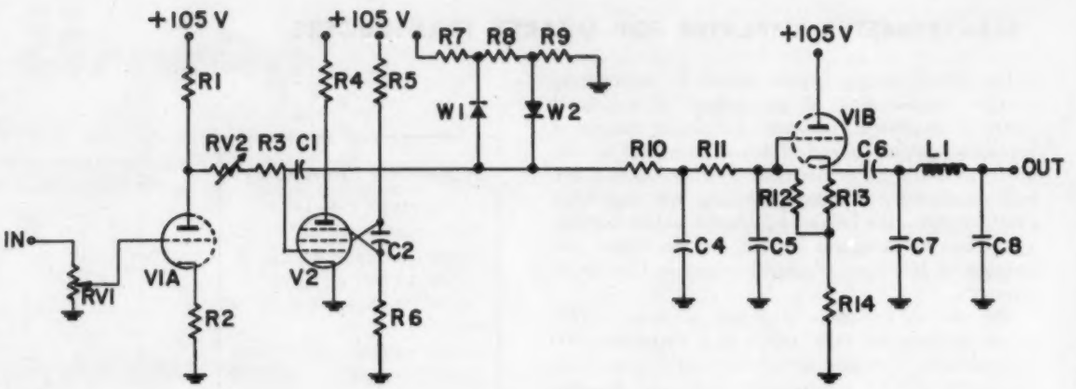


TABLE 1—COMPONENT VALUES: TUBES AND RESISTORS

V1			12AT7	R12	1	M-ohm ±10%
V2			6AM6	R13	2.7	K-ohm ±10%
R1	200	K-ohm	± 1%	R14	6.8	K-ohm ±10%
R2	3.9	K-ohm	± 1%	RV1, RV2	100	K-ohm wire-wound pots.
R3	1	M-ohm	± 1%	W1, W2		Silicon junction diodes
R4, R5	68	K-ohm	±10%	C3, C6		Ferranti ZS32A
R6, R10, R11	100	K-ohm	±10%			1μf, 150 v, electrolytic
R7	33	K-ohm	±10%			
R8	18	K-ohm	±10%			
R9	27	K-ohm	±10%			

TABLE 2—COMPONENT VALUES: CAPACITORS & INDUCTORS

VTU center frequency cps	C1 pf	C2 pf	C4, C5 pf	C7, C8 μf	L1 Hy.
626	2500	470	2300	.005	1.40
979	1500	330	1500	.004	.75
1536	1000	180	1000	.025	.53
2400	680	100	680	.015	.345
3756	400	75	390	.01	.220
5878	250	50	270	.005	.144

Source: D. H. Taylor, B. A., Road Research Laboratory, Dept. of Scientific and Industrial Research, Harmondsworth, Middlesex, England; also article page 524, Vol. 8 No. 7 *British Communications and Electronics, July* 1961.

ELECTRONIC WARNING SIREN

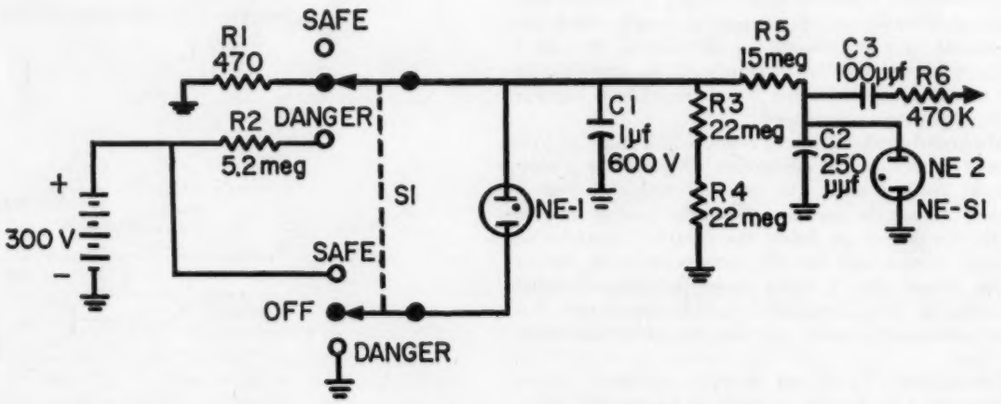
A low-power signal, for amplification by the public address system, is generated by the accompanying circuit. It was designed to provide a distinctive signal for warning of the beginning of cyclotron operation at a nuclear research facility. At this time all persons must be within shielded enclosures. A different tone signals the close of operation, when it becomes safe to enter the cyclotron area.

The DANGER signal starts at a low pitch, rises to a high note where it cuts off then repeats the upward sliding tone for as many times as the operator holds the switch in the DANGER position. The SAFE condition is signaled by an initial high pitch sliding to a low value, cuttng off, then repeating as long as the switch is held in the SAFE position.

Neon lamp NE-2 with R5 and C2 constitute a relaxation oscillator which generates a low frequency tone when supplied with low voltage and a higher note as the voltage rises. With the DPDT 3-point momentary contact switch in DANGER position, Capacitor C1 slowly charges through the 5.2 megohm resistor until NE-1 reaches its firing voltage (approx. 125 v). C1 then discharges through NE-1 causing the tone to recycle.

With the switch in the SAFE position, Capacitor C1 is instantaneously charged to nearly 300 volts by the firing of NE-1. NE-1 is extinguished when the potential difference across it becomes less than about 40 volts. The relaxation oscillator begins at a high note which becomes lower as C1 is discharged. When the voltage drop across NE-1 reaches its firing potential C1 is again charged, causing the tone to recycle.

With the switch in the center or OFF position, any residual charge in C1 is discharged through R1.

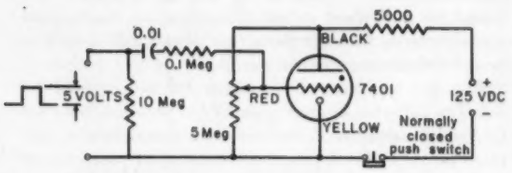


Circuit values are shown on the diagram. NE-1 is a Suneo type 5130 neon surge suppressor; any neon lamp with 125 v breakdown will work; NE-2 is a GE type 51 neon lamp, ¼ watt. Eveready type 493 battery will give service life approximately equal to shelf life.

Source: Edwin Laine, Lawrence Radiation Lab., Univ. of Calif., Livermore, Calif.

PULSE-OPERATED THYRATHON INDICATOR

The indicating properties of the cold-cathode thyratron Tung-Sol type 7401 subminiature tube, are utilized in the pulse-operated relay circuit shown. In this application, with the sensitivity control at maximum, a 5 v positive pulse applied to the grid will



SUBMINIATURE Indicator Tube Circuit

trigger the 7401 when 125 v dc is applied to the anode. By reducing the sensitivity, the circuit will fire when higher potentials are applied to the input terminals.

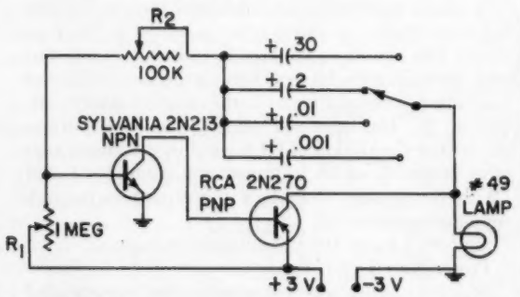
When the 7401 starts to conduct, removal of the input potential will not cause conduction to stop. The 7401 will continue to indicate as long as anode potential is applied. It can be reset by opening S1, a normally-closed push button.

Power supply: 110 to 125 v dc @ 20 ma.

Source: David M. Sanger, "Tung-Sol Tips", of Feb. 1961, Tung-Sol Electric Inc., 200 Bloomfield Ave., Bloomfield, N. J.

LOW-VOLTAGE TRANSISTORIZED STROBOSCOPE

The stroboscope shown in the accompanying circuit provides sharp sinewave flashes from 10 per second through 6000 per second, in four ranges, with the 30 μf selector position providing the low range. Increasing R1 increases the period between flashes, while increasing R2 increases the duration of the flash.



POCKET-SIZE stroboscope operating on dry cell is possible with this transistorized circuit.

The capacitors are 6v w dc types while the potentiometers are linear taper 1 watt types. The lamp is a miniature bayonet base, 2v, 60 ma lamp.

Source: Solar and Photocell Handbook, $2.00, International Rectifier Corp., El Segundo, Calif.

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VY 13 Axial Capacitor
Length 3/8"
Board Space Required 5/8"

Brand "X" Axial Capacitor
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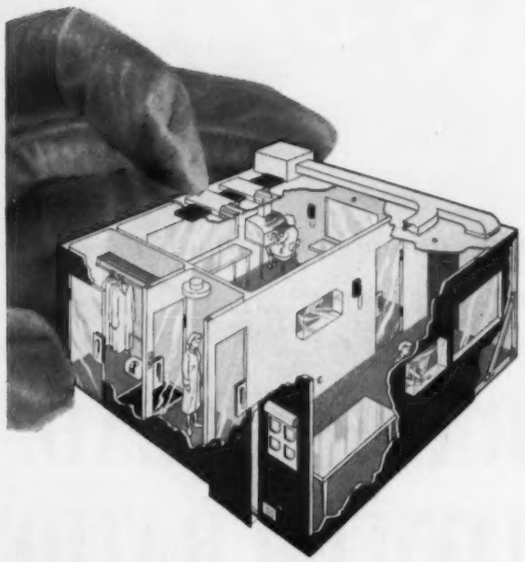

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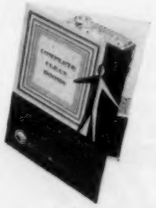

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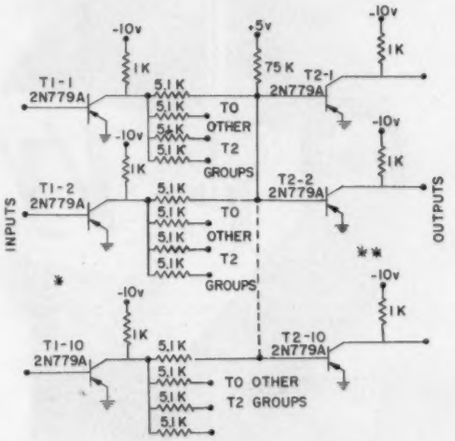
FAN-IN/FAN-OUT NOR CIRCUIT

Fan-in and fan-out high-speed NOR circuits require close control of saturation voltage spread and base-voltage spread in the transistors utilized. A circuit using from 5 to 10 inputs and/or outputs is shown which uses the Philco MADT 2N779A designed for NOR circuits using pulse rates up to 5 mc and for RC and diode logic circuits up to 50 mc.



FAN-IN and Fan-out NOR circuit using MADT 2N779A transistors is designed for pulse rates up to 5 mc.

Basically the NOR circuit is an inverter. A pulse of one polarity at the input produces a pulse of opposite polarity and of the same amplitude at the output. In the circuit, if all the T1 transistors are turned ON (conducting current as a result of a pulse applied at their inputs), then the ±5v supply through the 75K resistor provides a reserve voltage to T2 and transistor T2 is OFF. Should any one of the T1 transistors be turned OFF, then —10v will be available at its collector and this will provide enough current through its 5.1K coupling resistor to turn T2 (or all T2's) ON.

A single T1-T2 couple of this type can be wired to other couples to accomplish all logic functions. For example, two in series (1-T1 and 1-T2) will form a simple flip-flop if the output of the second couple is connected back to the input of the first couple. A two-input (2-T1's), one-output (1-T2) circuit forms an OR gate. AND gates and gated flip-flops can be made by other combinations.

Power requirements: (Single couple) Approx. 100 mw.

Pulse input: (Source resistance 5K), 10-v pk-pk min. (Lower input voltages will result in lower speed operation).

Source: C. D. Simmons, Philco/Lansdale, Lansdale, Pa.

ELECTRONIC CLOCK

Frequency stability better than ±1 part in 10^6 when operated in an ambient temperature which does not vary more than ±2°F is claimed for this circuit, a 100 kc transistorzied version of the Clapp-Pierce crystal oscillator.

Two 2N316 transistors connected in a composite common-emitter configuration are automatically adjusted for individual variation in transistor and crystal characteristics through the action of two 24B-2 switchboard lamps connected in parallel.

Bias for the base of transistor Q2 is provided by R2. The collector-emitter path of Q2 provides bias for Q1, and the emitter current of both transistors is supplied through R1. A positive excursion of potential on the base of Q2 will tend to diminish the forward emitter-base bias on that transistor, thus diminishing its emitter-collector current. This drives the base of Q1 more positive, which again diminishes the forward bias of Q2, causing it to approach cutoff. Amplifying action of both transistors is thus applied to diminish the emitter flow into Q1, and to bring the center-tap connection between C1 and C2 to its maximum positive potential. Due to the limiting action of the 24B-2 lamps (40

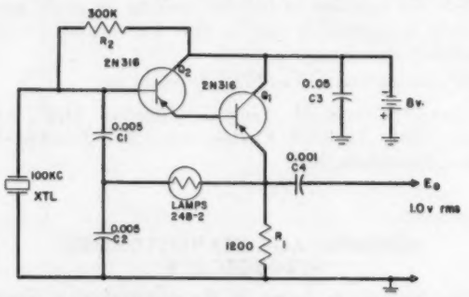


FIG. 5. SWITCHBOARD LAMPS stabilize Clapp-Pierce crystal oscillator circuit held within ±2° F from constant room temperature.

ohms max, cold), neither transistor enters a cutoff region.

The inductive-capacitive action of the crystal circuit then causes a swing in the opposite direction, furnishing a momentary negative-going potential to the base of Q2. This causes an increase in emitter-collector current, increasing the forward bias on the base of Q1 and a resulting surge of current in the emitter-collector circuit of Q1. The increased voltage drop in R1 drives the emitter connection of Q1 toward its maximum negative potential, which is transmitted through C1 and C2 to the crystal. Output of the circuit is through coupling capacitor C4.

Output: 1 v rms 100 kc sinusoidal voltage.

Power Supply: 8 v dc ± 0.5 v

Stability: When ambient temperature is controlled within ± 2°F, and an E cut crystal is used, frequency shift is approximately 1 ppm/°C about the crystal turnover temperature but as much as 4 ppm/°C at temperatures substantially above and below the turnover temperature.

Source: Mr. Thomas F. Marker, Automated Data Development Dept., Sandia Corp., Albuquerque, N. Mex.

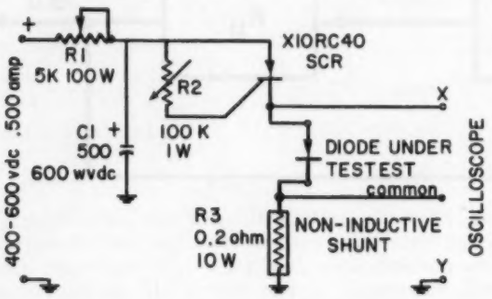
HI-CURRENT PULSE GENERATOR

The relaxation oscillator illustrated uses a silicon controlled rectifier to repetitively form high current pulses of exactly the same magnitude and duration. One application of such pulses is in the testing of forward characteristics of diodes.

In its nonconducting state the SCR blocks voltages to 600 PRV in both forward and reverse directions, depending on its rating. However, once it is triggered, the SCR will continue to conduct until its anode circuit is interrupted, the junction is reverse biased, or the current falls below its holding current value (the method used in this circuit).

The operation of the relaxation oscillator is as follows:

R1 and C1 form a conventional RC time constant



network across a dc source or 500 ma capacity at 400 to 600 volts. The SCR is connected across C1 in series with the test specimen diode and R3 (non-inductive current viewing resistor). Variable resistor R2, 100,000 ohms at 1 watt, is connected from the anode to the gate of the SCR.

When a dc potential is applied across R1 and C1, C1 starts to charge. The SCR is in the forward blocking state (OFF) and not conducting. When the potential across C1 becomes sufficiently high, the current through R2 will become high enough to trigger the SCR, switching it ON. The SCR has very low forward resistance and is in a low time-constant circuit, so the discharge of C1 through the test specimen is of very short duration. As the current through the SCR falls below the holding current value, the SCR switches OFF and C1 charges again to repeat the cycle.

Varying R1 with R2 fixed will result in constant pulse magnitude and varying repetition rate. Varying R2 with R1 fixed will vary both the pulse magnitude and repetition rate, with lower magnitude giving the higher repetition rate.

SCR Characteristics: Type 10RC40, Max PRV 400v dc; 10 amperes forward current at 25°C; Gate power, peak, 5 watts; max forward drop at rated current and volts, 1.25 v. Min holding current, 15.0 ma at 25° C. Peak currents of up to 200 amperes and approximately 200 μsec duration are possible from this circuit. If higher peak currents are desired, discharging through the primary of a current transformer will yield currents up to 1000 amperes or more.

Power supply 400 to 600 v dc at 500 ma.

Source: Ralph Rosa, International Rectifier Corp., in *IR Rectifier News*, Summer 1961, International Rectifier Corporation, El Segundo, Calif.

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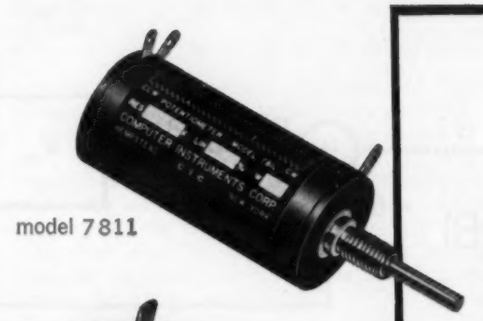
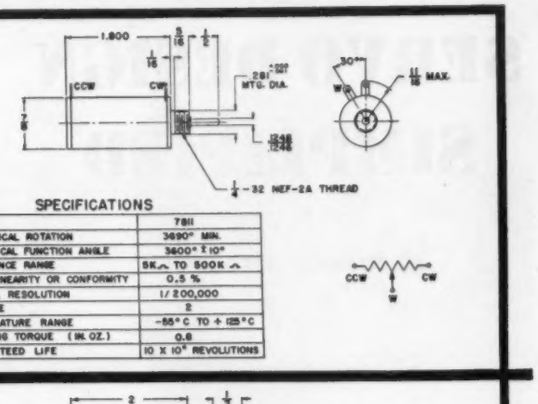


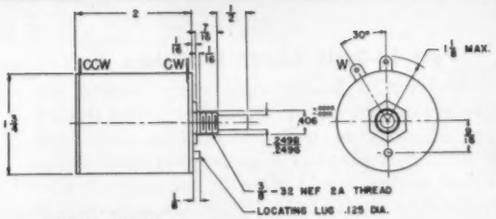
model 7811



SPECIFICATIONS

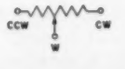
MODEL	7811
MECHANICAL ROTATION	3690° MIN.
ELECTRICAL FUNCTION ANGLE	3600° ± 10°
RESISTANCE RANGE	5K Ω TO 500K Ω
BEST LINEARITY OR CONFORMITY	0.5 %
VIRTUAL RESOLUTION	1/200,000
WATTAGE	2
TEMPERATURE RANGE	-55° C TO + 125° C
STARTING TORQUE (IN. OZ.)	0.8
GUARANTEED LIFE	10 X 10⁶ REVOLUTIONS

model 17511



SPECIFICATIONS

MODEL	17511
MECHANICAL ROTATION	3690° MIN.
ELECTRICAL FUNCTION ANGLE	3600° ± 10°
RESISTANCE RANGE	5K Ω TO 500 K Ω
BEST LINEARITY OR CONFORMITY	0.5 %
VIRTUAL RESOLUTION	1/400,000
WATTAGE	4
TEMPERATURE RANGE	-55° C TO + 150°C
STARTING TORQUE (IN. OZ.)	1.2
GUARANTEED LIFE	10 X 10⁶ REVOLUTIONS



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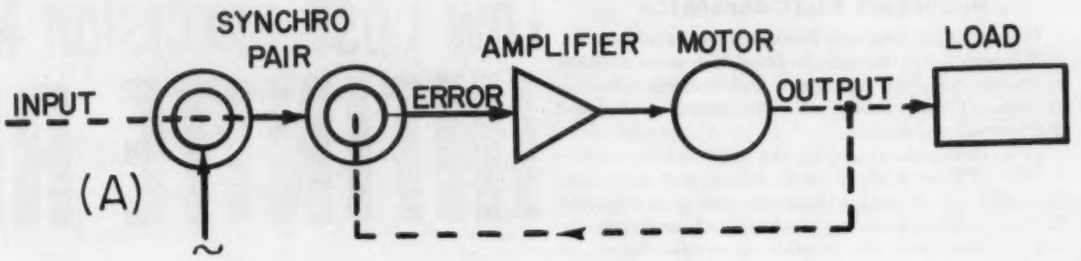
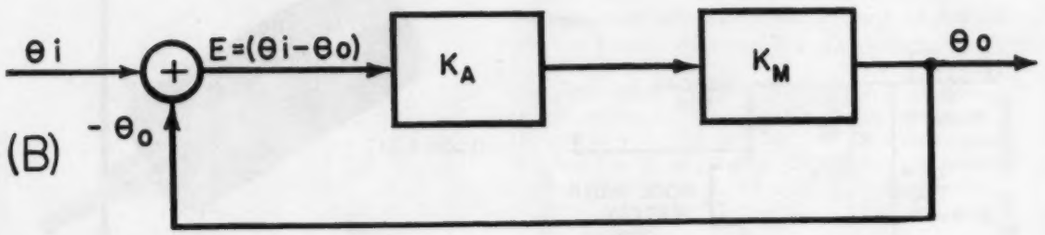


FIG. 1. SERVO SYSTEM of the second order.
(A) Functional Schematic; solid lines represent electrical signals, dashed lines show mechanical signals.
(B) Block Diagram, same system.



SERVO DESIGN SIMPLIFIED

by **HERBERT BREDEMEIER,**
M. Ten Bosch, Inc.

Part I—Basic Design Procedure

A servo system having two energy storing elements in the form of system inertia and torsional elasticity in the servoamplifier-servomotor loop is defined as a second order servo system. Design of this type system would normally require a lengthy mathematical analysis of the system components and system loop. A simplified design procedure using "servo building blocks", which achieves excellent results and minimizes design effort for second order linear systems, has been developed by M. Ten Bosch, Inc.

A typical second order servo system as indicated in Fig. 1, is composed of a synchro pair, and amplifier, motor and load. The input, θ_i, is compared with the output by the synchro pair to form the error signal, E. The error signal is augmented by the servo amplifier and applied to the motor. The output, θ_o, drives the load and provides the feedback to complete the loop. The differential equation for this system may be written as follows:

$$J\ddot{\theta}_o + \frac{J}{\tau_M}\dot{\theta}_o = K(\theta_i - \theta_o) - T_o \qquad (1)$$

Definitions. Before an attempt is made to design the servo system, certain symbol definitions, indicated in Table I, should be understood.

Selection of Components. The logical first step in the design of a servo system is the initial selection of components based on the desired performance and use of the system. The components selected at this time are the motor, amplifier and error measuring transducers which should be matched to each other and have linear characteristics.

After the sytem requirements have been established, values for T_o, J, T_M, S_M and E, as indicated in Table I, should be tabulated.

In a typical case the torque designated as T_o will be the sum of the torque required to overcome friction in the gear train and the torque required to drive the load. In certain noncritical servos, with relatively low output speeds, T_o is essentially the break-away torque of the motor which is typically 1/10 to 1/20 of the maximum torque, T_M.

The servo motor usually is an induction motor with rotor resistance sufficiently high to provide an essentially linear characteristic of torque vs speed. The characteristic of stall torque vs control phase voltage is also relatively linear. Therefore, the torque gradient, K_M, is a constant.

The value of J is the combined total of the motor moment of inertia, which may be obtained from the motor specifications, and the moment of inertia of the load, which may be determined by suitable tests or computation. Zero speed motor torque. T_M, and no-load motor speed, S_M, can also be determined from the motor specifications.

The open loop system gain, K, is the product of gains of the individual components. Thus for the system of Fig. 1-B:

$$K = K_E K_A K_M \qquad (2)$$

The output mechanism will normally contain shafts which, because of gear trains, run at speeds which are different from that of the motor shaft. When using certain of the quantities referred to in the above paragraph it is necessary that they be converted to equivalent values at one shaft, e.g. the motor shaft. If R is the ratio of a particular shaft speed to the motor shaft speed, the quantities associated with the particular shaft may be converted to equivalent quantities at the motor shaft as follows:

Quantity for Actual Shaft	Convert to Motor Shaft Equivalent by Multiplying by
Angle	R
Speed	R
Acceleration	R
Torque	1/R
Moment of Inertia	$1/R^2$

Computations. The next step of the design procedure consists of determining the time constant, τ_M, gain, K, undamped natural frequency, ω, and damping ratio, δ, of the system. These parameters are determined from the quantities tabulated previously.

If a simple connection is made between the ampli-

TABLE I. SYMBOL DEFINITIONS

T_o	Maximum torque to drive motor and load	(oz-in)
J	Moment of inertia of motor plus load	(oz-in sec²)
NOTE: 1 gm-cm² (cgs) ≡ 1.42 x 10^{-5} oz-in sec²		
T_M	Maximum motor torque at zero speed	(oz-in)
S_M	Maximum motor speed with no load	(rad/sec)
τ_M	Time constant of motor plus load	(sec)
θ_i	Input displacement	(rad)
θ_o	Output displacement	(rad)
$\dot{\theta}_i$	Input velocity	(rad/sec)
$\ddot{\theta}_i$	Input acceleration	(rad/sec²)
E	Total system error	(rad)
K	Open loop system gain	(oz-in/rad)
K_E	Synchro gain (sensitivity)	(volts/rad)
K_A	Amplifier gain	(volts/volt)
K_M	Motor gain (torque gradient)	(oz-in/volt)
ω	Undamped natural frequency	(rad/sec)
δ	Damping ratio	

fier and motor, the time constant of the motor and load combined is:

$$\tau_M = \frac{J S_M}{T_M} \quad \text{seconds} \quad (3)$$

If, however, feedback loops between the motor and amplifier are employed, τ_M must be modified accordingly.

The system gain K, must be sufficient to keep the system error from exceeding specified values with prescribed inputs applied. The total instantaneous system error, E, is the sum of static, velocity, and acceleration components as follows:

$$E = E_o + E_v + E_a \quad \text{radians} \quad (4)$$

where the static error

$$E_o = \frac{T_o}{K} \quad \text{radians} \quad (5)$$

the velocity error

$$E_v = \frac{J}{K\tau_M}\dot{\theta}_i \quad \text{radians} \quad (6)$$

and the acceleration error

$$E_a = \frac{J}{K}\left(1 - \frac{J}{K\tau_M^2}\right)\ddot{\theta}_i \quad \text{radians} \quad (7)$$

By substituting the prescribed values for error, input velocity, and input acceleration in the error equations above and solving for K in each case, a maximum value for the system gain is determined. For many applications the static error E_o is all that is specified. In these instances the values of K to be used will be merely $\frac{T_o}{E_o}$, where E_o is the total error. In instances where dynamic accuracy is important, the maximum input velocity or maximum input acceleration, or a critical combination of both, may be determined from the system specifications and the corresponding system gain calculated.

The undamped natural frequency, ω, and the damping ratio, δ, may be computed from the following equations:

$$\omega = \left(\frac{K}{J}\right)^{1/2} \quad \text{rad/sec} \quad (8)$$

$$\delta = \frac{1}{2\omega\tau_M} \quad (9)$$

Evaluation of Performance. The value of the damping ratio, δ, determined in the preceding paragraph, is significant in the determination of the second order linear servo system's performance. The value obtained for δ is associated with system performance as follows:

Values of δ	Damping	Remarks
0	None	Sustained oscillation
<1	Under damped	Fast response with overshoot*
1	Critically damped	Intermediate response with no overshoot
>1	Over damped	Slow response

*The first overshoot to a step displacement input is related to the damping ratio, δ, and the dimensionless time, ωt, for the output to settle within 1% of final value as follows:

Damping Ratio — δ	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
Overshoot — %	69	50	38	26	16	10	5	1.5	.9	0
1% Settling Time — ωt	44	23	16	11	8	6.9	6.2	6.2	5.6	6.9

Since both response and overshoot are important design considerations, a compromise value of $\delta = 0.5$ is often selected as a reasonable design goal.

If the damping ratio determined in this manner is acceptable, all that remains in the design of the system is the selection of the servo amplifier which together with the synchros and motor, will meet the maximum gain requirement previously established from the equations for error. This amplifier may be chosen from the complete line of M. Ten Bosch Tramp® servo amplifiers.

Upon completion of the calculations, the damping ratio may be found to be too great. In this event the system response may be improved by increasing the system's open loop gain, K. Since, as indicated previously, the gain is a product of the synchro gain, K_E, the amplifier gain, K_A, and the motor gain, K_M, the factor K may be improved by proper selection of the individual components.

In cases where the damping ratio has been determined to be too small, further design consideration must be given to the servo system. A review of the selected components should be made. For example, a different motor might be selected in order to improve the system performance by changing parameters such as the motor time constant or torque gradient.

A low damping ratio may also be improved, in a positive manner, by the addition of derivative control. This type of improvement may be obtained through the use of a rate generator, or for best results, through the use of the specially designed M. Ten Bosch LOR unit. This unit, when placed in the servo loop ahead of the amplifier, will result in a third order linear system. The design procedures to be used with the LOR unit and the third order system design, are similar to the procedures outlined here and will be discussed in a subsequent article.

BOOK REVIEWS

SOLAR CELL AND PHOTOCELL HANDBOOK, by John Sasuga (1960), International Rectifier Corp., El Segundo, Calif., 112 p., 6″ x 9″, $2.00. Principles and applications of photoelectric (selenium and silicon) cells. Includes characteristic curves and practical circuits.

FOR MORE INFORMATION CIRCLE 93 ON READER-SERVICE CARD

MATHEMATICAL HANDBOOK FOR SCIENTISTS AND ENGINEERS, by Granino A. Korn and Theresa M. Korn (1961), McGraw-Hill Book Company, Inc., New York 36, N. Y., 943 p., 6″ x 9″, $20.00. Definitions, theorems and formulas in algebra, analytical geometry, calculus, vector analysis, integrals Fourier analysis, Leplace transformations, differential equations, Boolean algebra, tensor analysis, probability theory, random processes, correlation functions, numerical computation and finite-difference methods.

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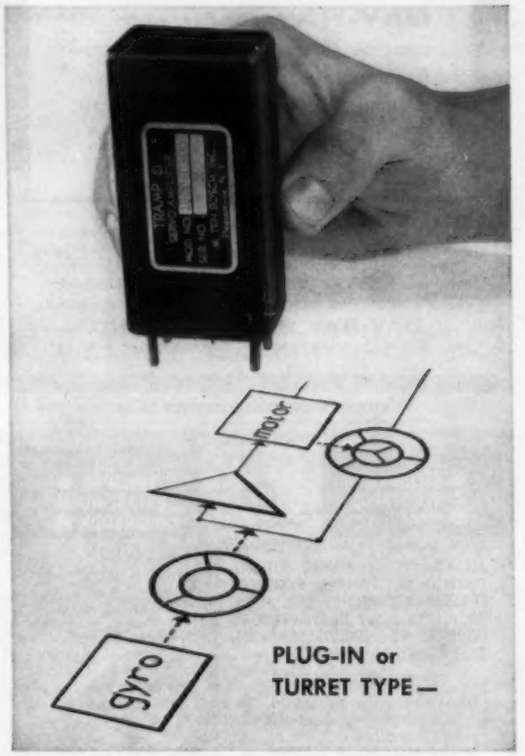

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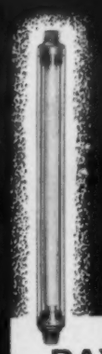

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Temperature Range: —55°C to +105°C and 180°C

Resistance Range: 10 to 125,000 ohms

Humidity Seal: Mil-E-5272 Proc I and Mil-Std-202 Method 106

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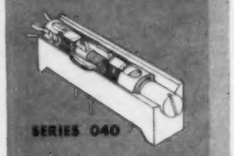

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Inertial Accelerometers

by Bernard Lichtenstein

Acceleration measuring devices that are most widely used (in inertial navigation systems) fall into three major categories; namely, force balance pendulous, vibrating string, and pendulous integrating gyroscope accelerometers.

Force Balance Accelerometers

These accelerometers consist essentially of a mass which moves along an acceleration-sensitive axis, and have a pickoff device which detects motion of the mass. Pickoff output resulting from mass motion is fed to a high-gain amplifier whose output current flows, in turn, through a force balance coil, producing the force necessary to return the displaced mass to null. This type of an accelerometer, together with its associated amplifier is, in effect, a high-gain null-seeking servo in which the current flowing through the force balance coil, measured as a voltage across a resistor in series with the coil, is directly proportional to the acceleration applied.

The design and fabrication of a force balance accelerometer is both simple and economical. A limitation frequently encountered, however, and one which can be overcome through the use of very high-gain loops, is the susceptibility of a force balance accelerometer to cross coupling acceleration errors attributable to the hangoff angle required for error signal generation. Since this type of accelerometer always operates about a null, very sensitive pickoffs can be devised for use with torques having a high degree of linear response.

Kearfott's C70 2401 003 accelerometer is a typical force balance type which employs an inverted pendulous mass together with a flexure type of suspension.

Generation of Digital Outputs

Though an accelerometer's normal output is an analog current proportional to acceleration, it is also possible to employ the force balance type in a manner such that its output is in digital form. In a technique known as pulse torqueing, a series of current pulses, each of which represents a discrete quantity of energy acting to drive the mass to null, is used instead of a restoring current that is continuous. The number of pulses required to null the accelerometer's proof mass is a measure of acceleration in digital form which can be used directly by a digital computer. Generation of pulses having the same energy content determines the proper function for such a system, while the digitalization itself is accomplished by the electronics associated with the accelerometer. The availability of new transistors having very rapid switching rates, coupled with newly developed circuitry, makes this method particularly attractive for advanced guidance systems.

A typical force balance pendulous accelerometer, utilizing a differential transformer type pick-off, a high gain capture amplifier and a dc permanent magnet force coil is illustrated in Fig. 1. The same design is shown in typical block notation form in Fig. 2. These typify many of the high precision force-balance accelerometers currently manufactured.

Vibrating String Accelerometers

The principle upon which these accelerometers operate is that a change in a taut wire's frequency is proportional to the square root of the wire's tension, a relationship depending on the wire's behavior according to Hooke's Law, i.e., strain is proportional to stress in an elastic material. Theoretically, such devices are particularly attractive because their output is directly in digital form, but metallurgical limitations

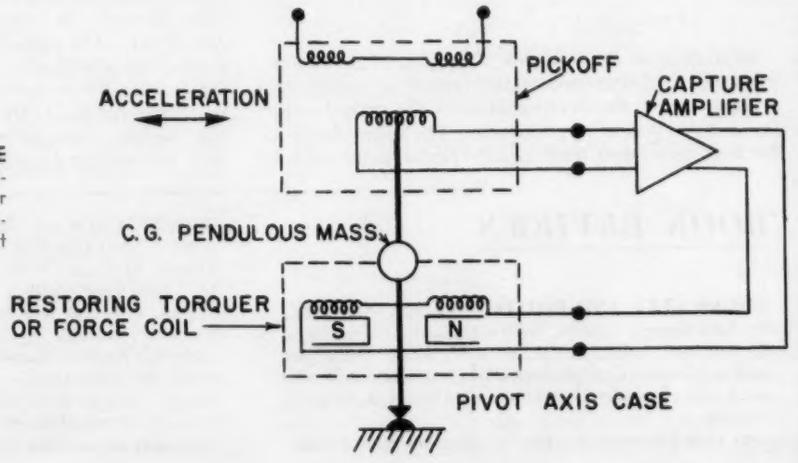
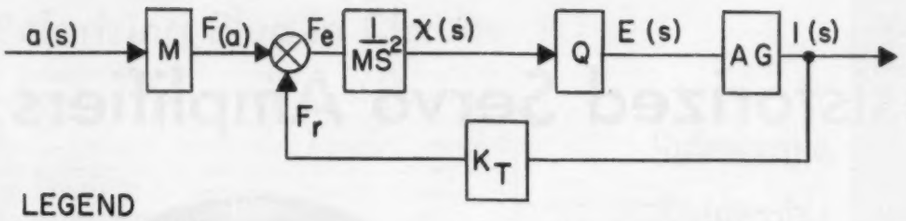


FIG. 1. FORCE BALANCE Pendulous Accelerometer utilizes a differential transformer pickoff, high-gain capture amplifier and a dc permanent magnet force coil.



LEGEND

a = acceleration
M = pendulous mass
F_a = force due to acceleration
F_r = restoring force
F_E = error
x = linear displacement of mass
A = amplifier gain
Q = pick-off scale factor
G = transfer function of shaping or stabilization networks and is in the form of a typical lag-lead network such as:

$$G = \frac{(T_1S + 1)(T_2S + 1)}{(T_3S + 1)(T_4S + 1)}$$

where T_1, T_2, T_3 and T_4 are time constants, and

S = LaPlace operator

The overall transfer function =

$$\frac{1}{a}(s) = \frac{QAG}{S^2 + QAG\,K_T/M}$$

FIG. 2. FORCE BALANCE Pendulous Accelerometer, Block Diagram.

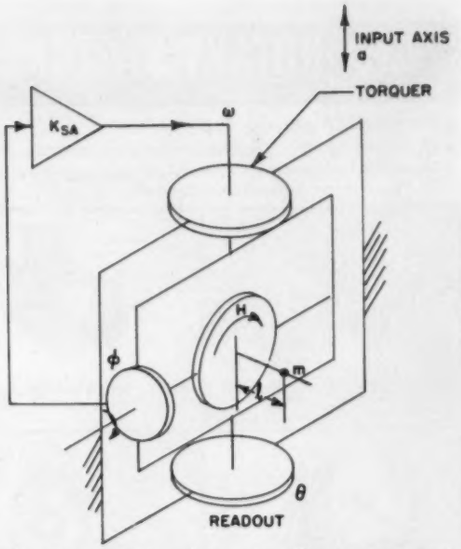


FIG. 3. PENDULOUS INTEGRATING Gyroscope Accelerometer.

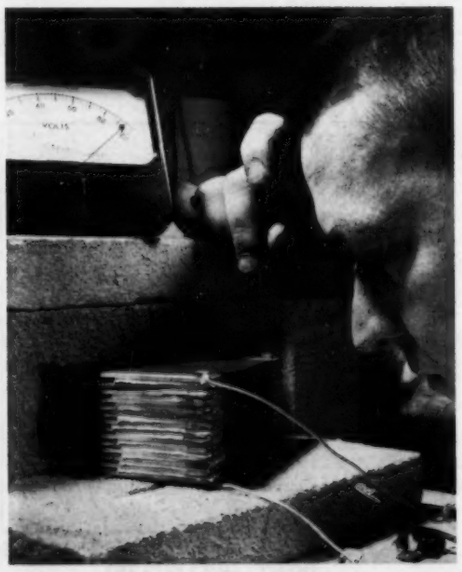
and complex associated electronics, together with the fact that high wire stress is not compatible with low metal creep, make it necessary to provide a means for relatively frequent calibration. However, this type of accelerometer is being used successfully in a number of ballistic missile systems.

Pendulous Integrating Gyroscope Accelerometer

A pendulous integrating gyro accelerometer (Fig. 3) may be considered to be a single axis gyro alignment loop in which an intentional unbalance is created in the gyro rotor. This unbalance, termed pendulosity, is the product of the mass multiplied by its moment arm from the gyro's precession axis. An acceleration along the input axis causes motion about the precession axis because of the mass unbalance. Mounted in a gimbal, the gyro is part of a null-seeking servo loop in which motion about the precession axis is detected by a pickoff whose output, after amplification, is fed to a gimbal torquer to cause relative motion between the gyro gimbal and its case. The torquer, positioned along the gyro's input axis, drives the loop to null, at which time gimbal angular motion is equivalent to the integral of input acceleration, which is velocity. A pendulous integrating gyro accelerometer is, in effect, a velocity meter . . . (*From* 60-*page* 8½″ *x* 11″ *booklet, Technical Information For the Engineer—Gyros", by Bernard Lichtenstein, P. E., Kearfott Division, General Precision, Inc.,* 1150 *McBride Ave., Little Falls, N. J.*)

FOR THIS LITERATURE CIRCLE 95 ON READER-SERVICE CARD

Ceramic Thermoelectric Generator



"LAYER CAKE" assembly of ceramic thermoelectric elements generates 95 volts dc in 2400°F heat from laboratory furnace.

Believed to be the first themoelectric generator made of ceramics, a new development made by Minneapolis-Honeywell for the Army's Picatinny Arsenal uses ceramic nickel oxide with a reference of platinum to operation at temperatures up to 2400°F. The output of the new ceramic generator is rated at 1,000 to 1,200 microvolts per degree C, compared with 250 to 300 for intermetallic thermoelectric generators. The pilot model illustrated is designed to deliver 100 volts under no load.

The ceramic unit is expected to convert "waste" heat from rocket exhausts and similar sources, which would destroy presently available thermoelectric generators. Appreciable currents are supplied by the new generator because it has low resistance at extremely hot operating temperatures.

The generator is made up of 14 ceramic plates, each sprayed on one side with nickel oxide and on the other with platinum. The oxide and metal are then scored with a diamond-bladed saw so they appear to be wrapped around each layer like an unbroken wire. A felt-like ceramic separates the layers and ceramic bolts and nuts hold the unit together. Steel melts at much lower temperatures.

Iron oxide will be substituted for platinum to produce even higher voltages in a second generator soon to be provided for the Army by the Honeywell Research Center, Hopkins, Minn.

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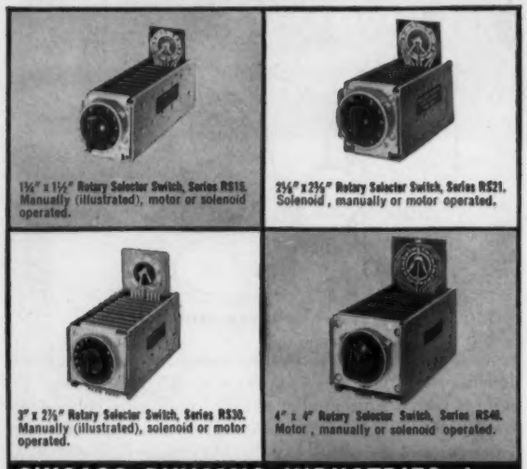

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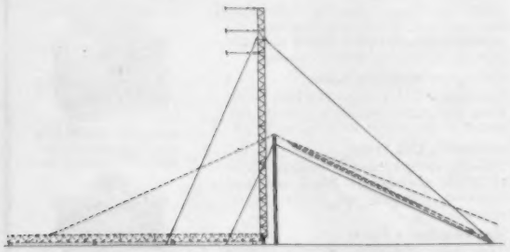
CIRCLE 19 ON READER-SERVICE CARD

Towers for Military Applications

The top portion of a 120-foot Trylon type 2400 tower for supporting one corner of a 3-wire rhombic transmitting antenna is shown in the drawing. This support is a higher version of the "standard 73'7" rhombic antenna tower," designated "AB-105C/FRC."

The tower has a pivoted base, insulated guys, and three antenna attachments.



It may be easily erected with a gin pole (Trylon type 1245) as shown. Military designation is "Erection Kit MX-746/FR."

Trylon towers and accessories for TV transmitting, large microwave, and other antenna installations are also available . . . (*From 8-page Trylon bulletin 3-3, Wind Turbine Co., West Chester, Pa.*)

CIRCLE 97 ON READER-SERVICE CARD

Transistorized Servo Amplifiers

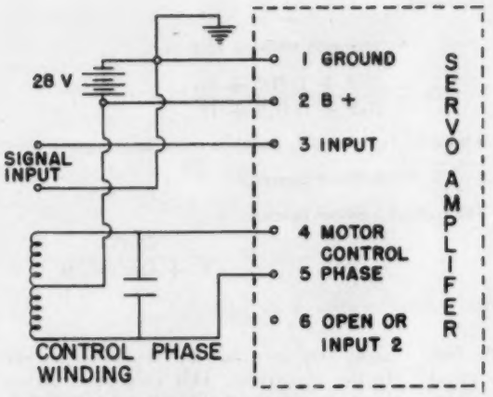


FIG. 1. TRANSISTORIZED Servo Amplifier linearly amplifies an error signal to control servo motors up to size 18.

Some form of servo amplifier is required with virtually all servo motors. The servo amplifier should match the error voltage source, whether it be a synchro, potentiometer, or other form of error detector—to the servo motor control phase.

This mission must be accomplished with a minimum loading effect on the error detector while presenting a low impedance source to the motor control phase. The servo amplifier's basic purpose is to linearly amplify an error signal to voltage and power levels capable of controlling the torque and motion of a servo motor.

The Daystrom line of servo amplifiers accomplish these requirements in driving servo motors up to a size 18. Virtually insensitive to temperature variations (Fig. 2), additional negative feedback is employed for voltage gains below 60 db, resulting in still better temperature stability. 60 cps and 400 cps types, both at 28 v are available.

As shown in Fig. 3, the amplifiers show a linear output vs input characteristic up to the region of rated power output. Here saturation is rapidly experienced, preventing serious overloading of the motor . . . (*From 16-page condensed catalog of Rotating Components, Transicoil Div., Daystrom, Incorporated, Worcester, Pa.*)

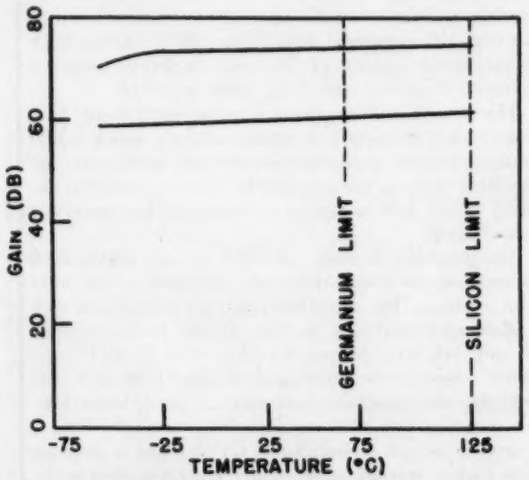


FIG. 2. ADDITIONAL negative feedback for voltage gains below 60 db results in essentially flat temperature characteristics.

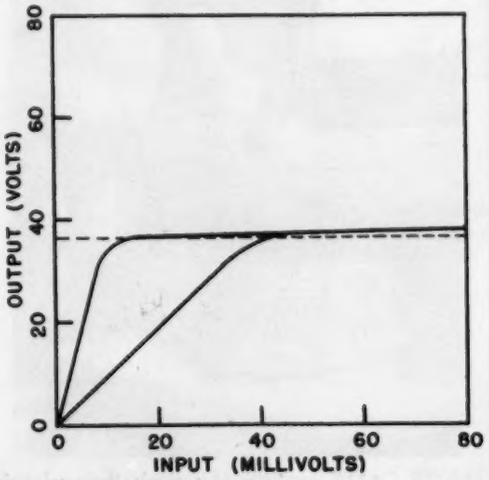


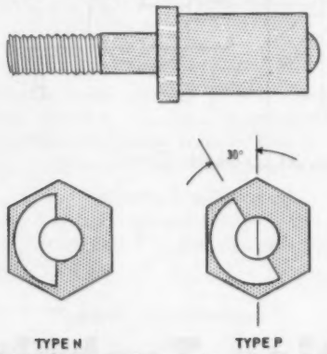
FIG. 3. OUTPUT/INPUT curves at low and high gain settings are linear up to rated power, where saturation prevents overloading.

CIRCLE 98 ON READER-SERVICE CARD

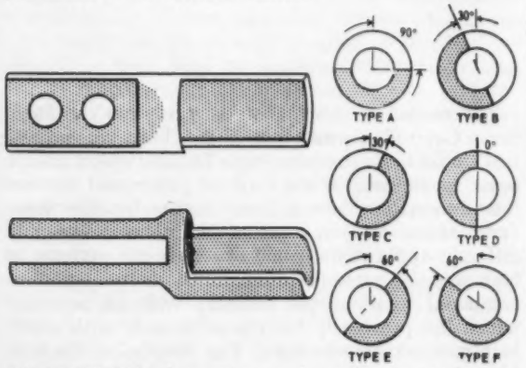
Polarizing Plug-in Circuits

Designers and users of modular circuit board assemblies are often troubled by the possibility of inserting a circuit board in the wrong socket, with consequent damage to circuits, connectors and contacts. Conventional keying devices obviate this danger, but because they alter the integrity of the connecting elements, troubleshooting and maintenance become difficult.

Polarite polarizing plugs* not only eliminate the danger of inserting a wrong card, but do not alter the connectors electrically or mechanically. The Polarite plug consists of a socket and a mating stud. Studs are available in two configurations (N- and P-types shown), while the sockets are made in six unique configurations, each receptacle being displaced 30° with reference to the plane of the mounting slot.



TWO STUD TYPES are fastened to the edge connector by means of a hex mounting bolt extension, can be positioned in 12 discrete indices.



SIX SOCKET Configurations, each can be mounted in two 180° apart, providing twelve configurations. Using two plugs per board, 120 combinations are possible.

Rotation of the slot on the mounting plane 180° provides an additional six indices. Sockets can thus be eyeletted to the shoulder of the modular board in 12 discrete indices. This results in 144 discrete combinations of studs and sockets on a board on which the shoulders are offset. . . . (*From 4-page Polarite Bulletin* 6120, *The Ucinite Co., Div. of United Carr Fastener Corp., Newtonville* 60, *Mass.*)

* U. S. and foreign patents pending

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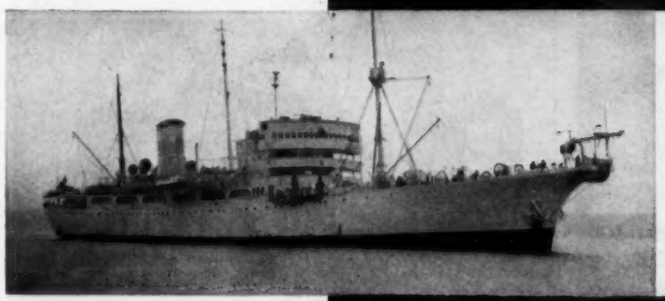

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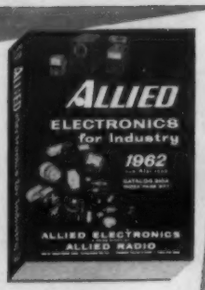

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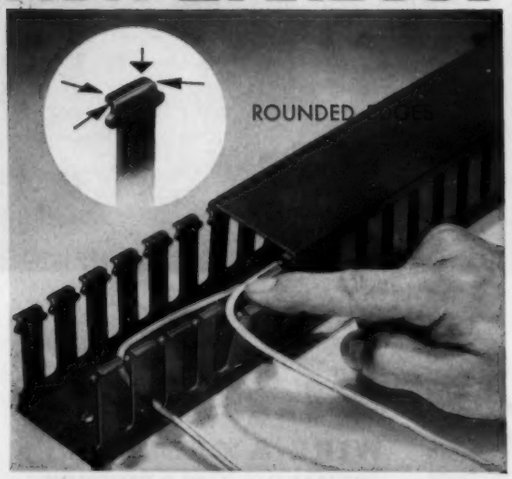

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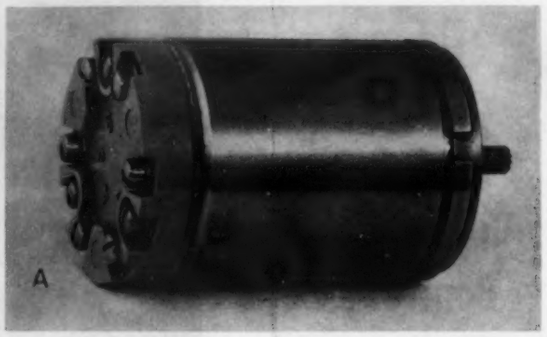

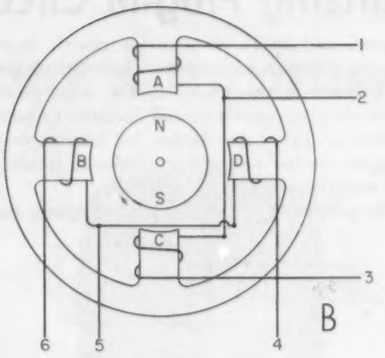

FIG. 1. STEP SERVO MOTOR (A) Assembled View. (B) Schematic Circuit.

Step-Servo System is New Automation Technique

by Walter E. Peterson and Bernard Van Emden

STEP-SERVO Motor and Controller developed by the Automation Development Corporation, 11824 Jefferson Blvd., Culver City, Calif., employ a digital servomechanism technique having numerous applications in both military and industrial automation programs.

Heart of the system is the Step-Servo Motor (Fig. 1), using a permanent magnet rotor actuated by dc currents in a wound stator. A dc current in one winding of the stator causes the rotor to turn so that its poles are in line with the stator field. Transferring the current to an adjacent winding causes the rotor to make an incremental turn either clockwise or counterclockwise, depending on which coil is activated.

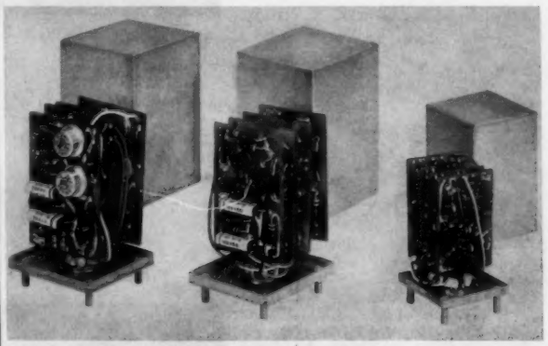

FIG. 2. CONTROLLERS for Step-Servos are computer type circuits designed for the particular aplication and packaged in hermatically-sealed cans.

The second component of the system is the Step-Servo Controller, which acts as the "brain" of the system. It contains computer-type circuits which accept input intelligence in the form of pulses and convert this information into a form usable by the Step-Servo Motor. Various types of controllers are used in different applications, some of which can perform at high stepping rates (more than 200 ninety-degree incremental rotations per second) with an accuracy which has previously been possible only with costly high-gain servomechanisms. The Step-Servo Controllers use semiconductor circuits assembled on etched circuit cards which are packaged in hermetically sealed MIL-T-27A cans (Fig. 2).

Considerable versatility in the method of servo stepping is possible with the standard 4-pole motor. 90° incremental stepping results from the sequence A, B, C, D (counterclockwise) or A, D, C. B(clockwise). A 45° incremental clockwise movement will result from the sequence A, AD, D, DC, C, CB, B, BA, etc. A 180° counterclockwise rotation will result from the sequence A, Pulse B, C, Pulse D, A, etc. By "Pulse" it is referred that the coil would be momentarily energized only long enough to determine the direction of rotation.

Transistor circuits in the controller are used to remember the previous coils energized and to energize the next coils on command. When no command is received, the last coils turned on remain on, holding the motor in the last commanded position (detenting). Because no ratchets or other mechanical detents are used, the load connected to the output shaft receives

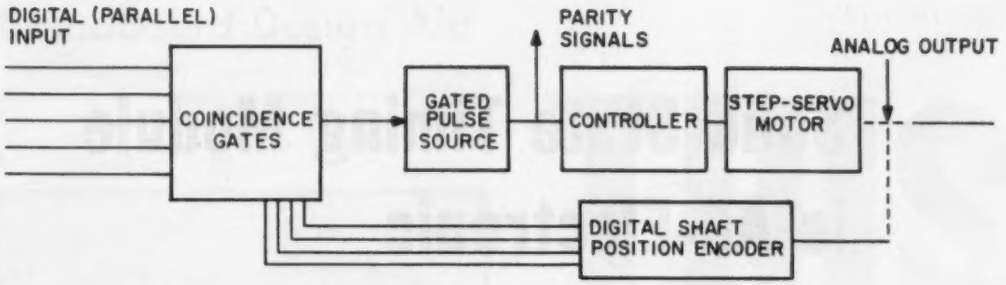

FIG. 3. DIGITAL POSITION Servo accuracy is determined by position encoder used.

a smooth incremental rotation without undue wear.

The basic dynamic equation governing the operation of a Controller-Motor combination is:

$$T_{max} \cos \theta = J\, d^2\theta/dt^2 + fd\,\theta/dt$$

where T_{max} is the torque when a new 90° rotation is commanded, θ is the angle of rotation, t is time, J is the system inertia and f is the damping constant of the system.

Typical Applications

Digital-to-Analog Converter and Pulse Counter. A pulse fed to the Step-Servo Controller causes an output to the motor that produces one 90° incremental rotation per pulse in either a clockwise or counterclockwise direction at rates exceeding 200 pulses/second. The output can be directly coupled to the load or through a gear head to achieve the accuracy and torque desired. Input intelligence can be derived from punched tape, magnetic tape, knob, push-button dial programmer or computer programmer.

The motor can drive potentiometers, X-Y plotters, counters, frequency tuners, switches, control surfaces, servo valves, instruments or transducers of other types. By using the motor to drive a mechanical counter, an accurate pulse-counting method is achieved.

Digital Position Servo. An input digital (binary) command signal is compared to the output of a digital shaft position encoder by a series of coincidence gates (Fig. 3). If the two do not coincide, a gate-pulse generator is allowed to pulse a Controller Step Servo Motor combination moving the position indicator until coincidence is acheived. A parity (correctness) signal may be obtainecd as a side product and used to check for proper operation. The accuracy of this system is determined by the encoder used. Encoders capable of dividing a circle into one part in 2^{19} are commercially available.

Analog-to-Digital Conversion. An input analog dc voltage is applied to the input terminals. This input voltage is compared with the output of a followup potentiometer. The difference between input and follow-up is amplified and used to gate the output of a pulse generator to drive a Step-Servo Controller and Motor, which moves the potentiometer until a null is obtained (Fig. 4). The output of this arrangement is a chain of pulses, the number of which depends on the magnitude of the initial error signal (non-weighted binary). If these signals are connected to an add-subtract circuit, weighted binary signals in parallel or serial form may be obtained.

The foregoing are only a few of the possible applications of the Step-Servo Motor and Controller combination. Available in standard Buord sizes from 5 to 23, with torque ratings from 0.2 to 20.0 oz-in, other sizes up to several horsepower are manufactured to customer specifications.

FOR MORE INFORMATION CIRCLE 468 ON READER-SERVICE CARD

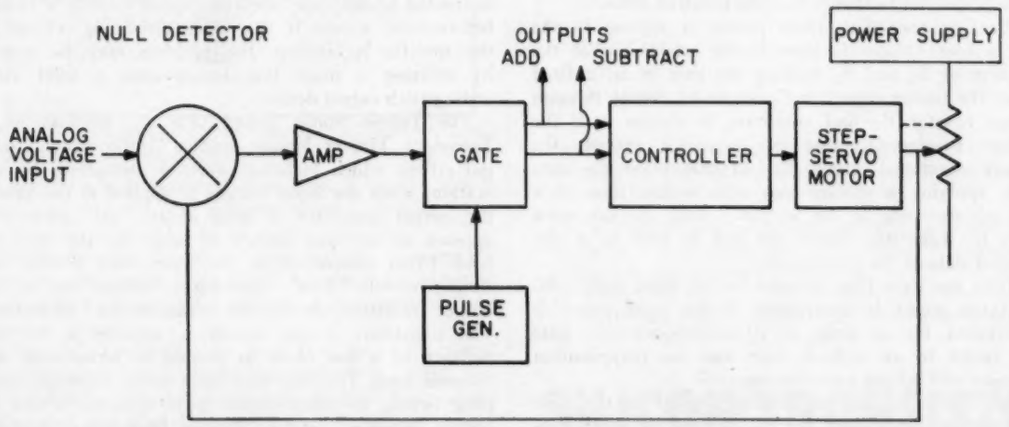

FIG. 4. ANALOG-to-Digital Conversion. Analog input dc voltage is compared by null detector with potentiometer output. Error signal gate pulse generator output to drive step servo to null.

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Now, however, Chicago Miniature's lamp engineers have taken another step to insure *reliable* performance. They have designed a double filament lamp in which one filament serves as the principal light source;—the second is long lived! When the first filament burns out, the second continues to operate, performing its function as a signal lamp, but with reduced candlepower,—a warning that replacement is necessary.

This is just one more example of Chicago Miniature's many contributions to product reliability. For more complete information write for data on double filament lamps,—now available in several styles and sizes.

Write for Bulletin 1105—Miniature Lamp Data Book

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CIRCLE 26 ON READER-SERVICE CARD

Solid-State Timing Module is All-Electronic

The basic Tempo RC Timing Module, as shown in the accompanying diagram, consists of an RC timing network, a transistor gate circuit, a resistor bias network and a transient suppression circuit. Since the output circuit has no effect on the timing module, it can be considered to be external to the module.

The characteristics of the gate circuit are such that when point A is more positive than point B, the gate is held in an unfired state and appears as an exceptionally high impedance in parallel with the timing capacity C_T. Simultaneously, the gate presents an impedance in the order of several megohms in series with the output circuit. However, when point A becomes

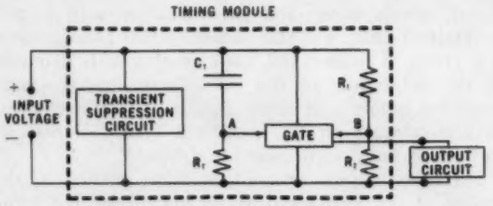


FIG. 1. BASIC TIMING module circuit schematic.

a few millivolts negative with respect to point B, the gate fires and locks in a fired state causing the impedance in series with the output circuit to change to a few ohms, and the impedance in parallel with the timing capacitor to change to a few hundred ohms.

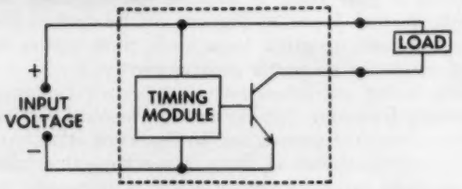
Thus, in operation, when power is applied to the unit a bias voltage is immediately established at the junction of R_1 and R_2 holding the gate in an unfired state. The timing capacitor C_T begins to charge through timing resistor R_T and continues to charge until the voltage developed across the capacitor exceeds the voltage developed across R_1. At this point the gate fires, applying a voltage step with a rise time of a few microseconds to the output circuit. At the same time, the capacitor discharges and is held in a discharged state by the gate circuit.

When the gate fires it locks in the fired state until the input power is interrupted. If the input power is interrupted for as little as 10 milliseconds the gate will revert to an unfired state and the reapplication of power will initiate a new timing cycle.

The reset time of an electronic timer is the time required for the output device—a relay or solid state static switch—to revert to the state existing prior to the completion of a timing cycle. In the case of a delay-on-pull-in timer (DOPI) it will be the maximum time required for the relay to drop-out after the timer power has been interrupted. Relay output timers reset typically in 10 milliseconds after the interruption of power.

The relay transfer time is the period during which

FIG. 2. STATIC TIMER module and application circuit. The solid state timer is particularly indicated where brief break-before-make period of relay contacts cannot be tolerated.



the relay armature appears as an open circuit as it transfers between contacts. This period, typically 5 milliseconds in duration, is important only when very short time delays are required or when the circuit connected to the relay contacts cannot tolerate a break-before-make action. If this characteristic is critical in the specific application, the problem may be solved by utilizing a timer that incorporates a solid state static switch output device.

The Tempo Static Timer (Fig. 2) consists of a Transistor Timing Module and a "static switch" output circuit which includes overload protection. In operation, when the input voltage is applied to the timer, the output transistor is held in an "off" state and appears as an open switch in series to the external load. Upon completion of the time delay period, the timing module "fires", applying a voltage step to the output transistor, driving the transistor into saturation. The transistor, in this condition, appears as an impedance of a few ohms to ground in series with the external load. The load may be a relay, solenoid, stepping switch, or other digital logic element. (*From 5-section looseleaf catalog, Tempo Instrument Incorporated, P. O. Box 338 Hicksville, L. I., N. Y.*)

CIRCLE 100 ON READER-SERVICE CARD

Breadboard Design Aid

Circuits are quickly assembled on the CSL Circuit Builder (Fig. 1) by inserting component leads and jumper wires into individual junction cells.

Each cell acts as an electrically isolated tie point for all wires inserted into it. The cell consists of a gold-plated

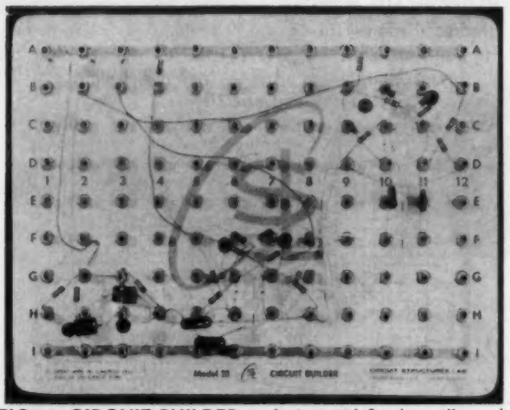


FIG. 1. CIRCUIT BUILDER is design aid for breadboarding developmental and experimental circuits, particularly of analog and computer devices. Tested circuit is quickly transferred to companion CSL Circuit Cards.

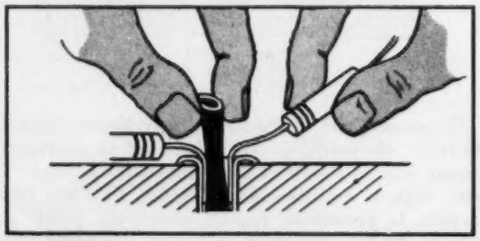


FIG. 2. RUBBER core in gold-plated eyelet shrinks when it is pulled to admit component leads and conductors.

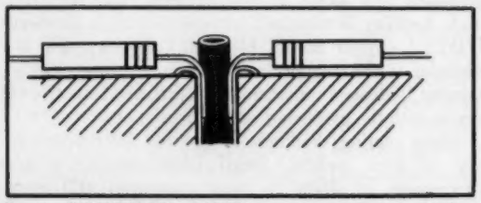


FIG. 3. EXPANDED CORE presses component leads tightly against goldplated eyelet, making firm contacts.

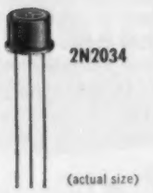
eyelet and a long-wearing rubbed core. When the core is pulled upward, the core diameter shrinks, allowing wires to be easily slipped inside the eyelet (Fig. 2).

When released, the rubber core expands, pressing the wires or component leads firmly against the gold-plated surface and establishing a contact of essentially zero resistance (Fig. 3).

The CSL circuit builder is a first step. The tested breadboard circuit is quickly transferred to a CSL Circuit Card for efficient protype production of a variety of analog and digital devices . . . (*From new 6-page folder, Circuit Structures Lab., Laguna Beach, Calif.*)

CIRCLE 101 ON READER-SERVICE CARD

THIS



2N2034

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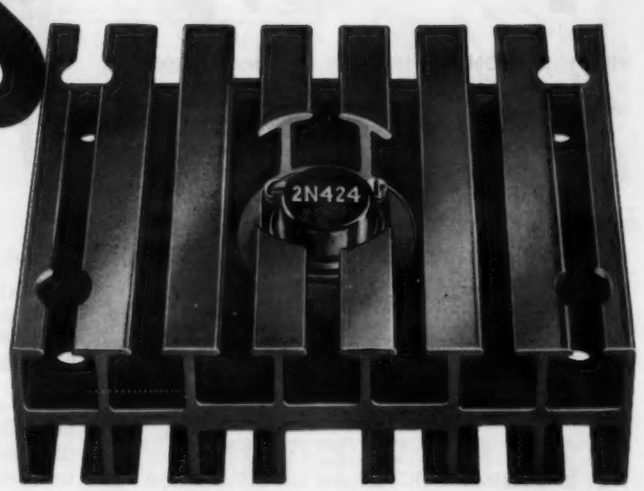
REPLACES

THIS



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From STC . . . A Significant Technological Breakthrough . . . Miniaturized High Power Silicon Transistors That Don't Require Heat Sinks.

STC's 2N2034 with saturation resistance under 0.3 ohms at 1.0 amps in the TO-5 package improves power switching circuit efficiency by 97% as compared with the 10 ohm 2N424 mounted in a heat sink as illustrated above. Specs: H_{FE} 20 to 60 at 1 amp; BV_{CES} 80 volts min; Ic = 3 amps.

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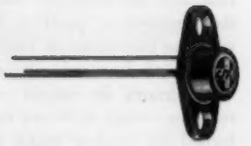


The 2N2035 in the TO-8 package and the 2N2036 in the TO-37 package with higher power dissipation are also available.

SILICON TRANSISTOR CORPORATION

CARLE PLACE, L. I., NEW YORK, Ploneer 2-4100

CIRCLE 27 ON READER-SERVICE CARD

Silicon Rectifier Assemblies

Reliable sources of dc power for operation up to 190°C junction temperature are available in a wide range of voltage and current capacities. Typical of the hermetically sealed silicon units produced by the Fansteel Rectifier-Capacitor Division, the Type 9A unit, shown singly and in the single-phase full wave bridge assembly on 3″ square copper in Fig. 1, is available in rms voltage applications from 35 v to 426 v. All Type 7B rectifiers are rated at 12 amperes in halfwave circuits.

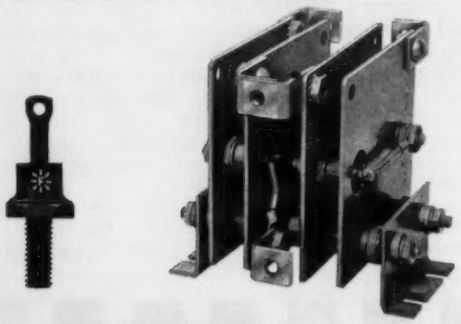


FIG. 1. SILICON Rectifier Type 7B is shown single and in full-wave bridge assembly on 3" copper heat sink plates.

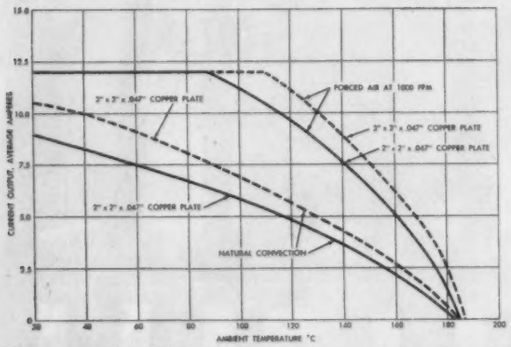

CURRENT OUTPUT, AVERAGE AMPERES
AMBIENT TEMPERATURE °C
FORCED AIR AT 1000 FPM
3" x 3" x .042" COPPER PLATE
2" x 2" x .042" COPPER PLATE
NATURAL CONVECTION

FIG. 2. MAXIMUM DC Output per cell for Type 7B rectifier. Other rectifier types, from 6 up to 370 ampere, 600v ratings, are available.

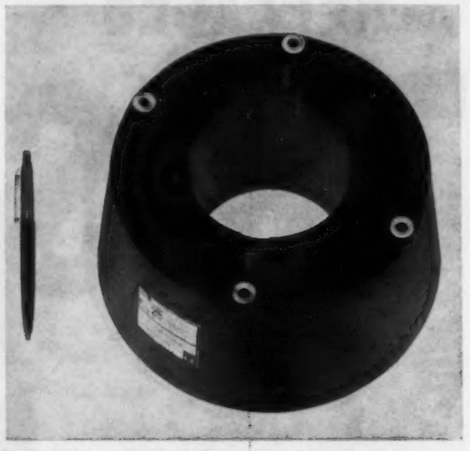
The Fansteel stud-mounting Silicon Rectifiers are hermetically sealed and have exceptional resistance to shock and vibration. They can be mounted in any position and are supplied with the mounting stud as either the negative or positive terminal. Each unit is marked with the conventional rectifier symbols indicating the direction of forward current.

Maximum dc output current per cell for Type 7B rectifier versus ambient temperature for convention and forced air cooling when mounted on copper heat sinks is shown in Fig. 2. The value of current per cell is also the current provided by a single phase half-wave circuit. It is multiplied by 2 for the total output of a single-phase centertap or bridge circuit, by 3 for a three-phase full-wave circuit and by 6 for a 6-phase circuit using interphase transformers . . . (*From new 44-page catalog, Rectifier-Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.*)

FOR THIS LITERATURE CIRCLE 102 ON READER-SERVICE CARD

Digital Programmer is Arming-Fuzing A-Weapon Component

An all-electronic digital timing programmer having an accuracy better than 0.1% under extreme environmental conditions, and comprising two identical although independent programmer channels, is being used as part of an arming-fuzing system for an atomic weapon. Solid-state circuits for the two channels are contained on five printed circuit disks, each of which is potted in rigid polyurethane foam. The potted disks are then bolted together and interconnected, and the entire assembly is mounted in an outer shell (see Figure) and the voids filled with silicone rubber. This technique minimizes mechanical resonances over a wide range of vibration frequencies.



A-WEAPON ARMING-FUZING dual four-stage Timer circuit is encapsulated in ordinary-looking toroid. All solid-state electronics provides highest reliability under extreme environmental conditions.

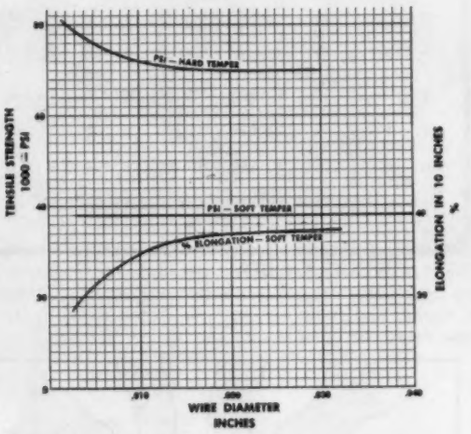
Developed by Tempo Instrument Incorporated of Hicksville, N. Y., under contract with the Army's Picatinny Arsenal, Dover, N. J., the programmer has a four-stage, adjustable timing program suited to a wide range of other military and industrial applications requiring highest standards of safety, reliability and accuracy. The circuit maintains its required accuracy under temperatures ranging from —65° to 165°F, voltage variations of 26.5 v ±5.5 v dc, variation of 50 G at 2,000 cps and 100 G shocks and accelerations.

The solid-state digital timer generates an accurate time base, counts the generated pulses, and senses the preset time with AND gates, achieving a timing error not greater than 0.1 second over the timing program of approximately two minutes duration. The same technique is capable of extension to any number of functions, limited only by the unit's allowable physical size, according to Tempo engineers, specialists in modular electronic timing devices and controls.

FOR MORE INFORMATION CIRCLE 103 ON READER-SERVICE CARD

Silver Plated Copper Wire

Single end[1] electrolytic copper uniformily electroplated with a continuous non-porous coating of pure silver is specified in a number of military specifications. MIL-C-17C, MIL-W-16878D, MIL-W-7139B, MIL-W-8777B, MIL-W-22759 and NAS 703 all state: "'Silver plating thickness to be not less than 40 micro-inches." In addition, the last four specifications also add that minimum elongation, as measured by stretching a 10" sample until it breaks, must be 10%.


TENSILE STRENGTH 1000 = PSI
ELONGATION IN 10 INCHES %
PSI — HARD TEMPER
PSI — SOFT TEMPER
% ELONGATION — SOFT TEMPER
WIRE DIAMETER INCHES

Elongation and tensile strength of Hudson high-conductivity electrolytic copper wire used in silver plated copper wire is shown in the accompanying graph. This base metal is available in two grades, ETP and OFHC. Oxygen is present in regular electrolytic tough pitch copper (ETP) as cuprous oxide particles which are almost completely insoluable in the solid metal. For most purposes this oxide is not harmful, but if extremely high ductility is required, oxygen free high conductivity (OFHC) copper should be used. Cuprous oxide is also harmful if the copper is heated in an atmosphere containing hydrogen since this gas diffuses into the metal, reacts with the oxide and causes brittleness.

Silver plating thickness is ordered by percentage silver of total weight. Small wires require a greater percentage of silver to meet minimum MIL-Spec requirements. Thus a wire 2.8 mils in diameter plated to a thickness of 41 microinches will be 6.10 % pure silver, whereas a wire 15.9 mils in diameter plated to the same thickness will be only 1.25% silver. Plating machines at Hudson are designed to use a large number of passes through the plating solution at low current density to achieve fine-grained deposits. Special dies and drawing compounds are used to reduce the silver plated wire to finished sizes, where it can be annealed and respooled to any specified package size . . . (*From 4-page Bulletin OW-1001, Hudson Wire Company, Ossining Division, Ossining, N. Y.*)

[1]Single End refers to single strand wires as differentiated from "multi-ended" wires or cables.

FOR THIS LITERATURE CIRCLE 104 ON READER-SERVICE CARD

Sending RAW DATA from MARS!

Unprecedented opportunities are now available for communications engineers and system design engineers at Remington Rand Univac in St. Paul on MARS — the Mobile Atlantic Range Station project.

MARS is a precision tracking system involving the Univac 1206 Real Time Computer and Univac data handling sub system.

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COMMUNICATIONS ENGINEERS should have EE degree, plus 3 or more years heavy experience in high speed, long range digital transmission systems. Experience with missile range information accumulation and transmission valuable. Should have RF experience.

Additional openings are also available for PROGRAMMERS and SYSTEMS ANALYSTS at both St. Paul and a new facility being established in the Cocoa Beach, Fla., area.

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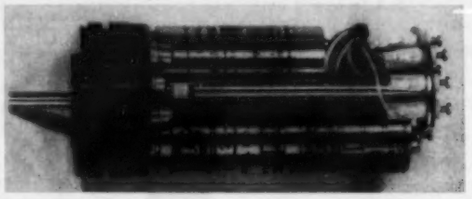
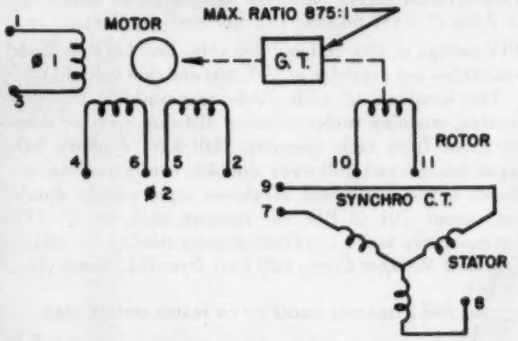
CIRCLE 105 ON READER-SERVICE CARD

Integrated Servo Assembly

Remote transmission of angular positions with accuracy and torque gradient better than hitherto obtainable in self-synchronous systems of frame size 5 are provided by a new integrated servo assembly containing a size 5 motor, a size 5 control transformer and precision gearing in a size 11 housing. It is designed for use with any Transicoil servo amplifier or is available integrated wth its own amplifier in a slightly larger housing. The output shaft positions itself to agree with 3-wire electrical inputs received from any synchro control transformer.





INTEGRATED SERVO package shown in assembly with cover removed comprises all functions schematically shown in diagram below.

The integrated servo assembly is available as a prefabricated component in servo indicators, gear ratio devices, timing devices, analog computers, and automatic control systems. Replaceable as a module, it eliminates replacement and servicing problems caused by individual failure. The servo assembly is a development of the *Transicoil Division of Daystrom, Inc., Worcester, Pa.*

FOR MORE INFORMATION CIRCLE 106 ON READER-SERVICE CARD

SOLID-STATE DEVELOPMENTS

including New Microcircuits, Thin Films and Power Transistors are emphasized in the January-February 1962 issue of Military Systems Design. Advertisers have 'til January 10 to order space.

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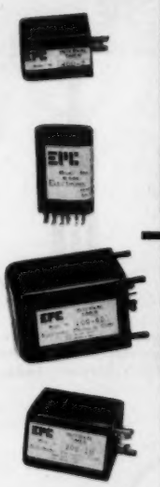

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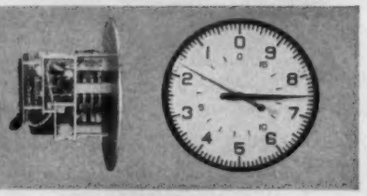
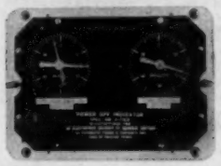
MIL-SPEC TIMERS AND PICK-OFFS

Countdown Controllers accurately show split-second, continually corrected visual missile countdown sequence. Electrically synchronized with actual count.

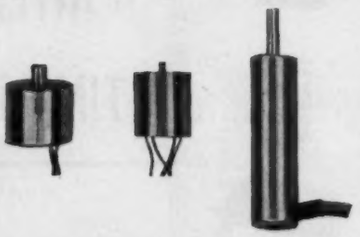


Elapsed Time Indicator gives visual check of power interruptions. Tied in with missile power supply from final assembly to launching. Records length of individual interruptions and total time off.



Transistorized Time Delay Relay (left) controls timing intervals from 50 milliseconds to 5 minutes. Made in 72 forms. **Hermetically Sealed Delay Timer** (right) provides fixed or adjustable time delay for repeat and reset cycle delay timing and sequencing for missiles or ground support equipment.

Atcotran Differential Transformers are electromechanical transducers for measuring linear motions. Three ATC mil-spec approved types, 6210-K (left) 6207-K (center) and 6203-K (right) give unprecedented reliability as displacement pick-offs for altimeters, pressure cells, servo feed-back signals, etc.



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AUTOMATIC TIMING & CONTROLS, INC.
KING OF PRUSSIA, PENNSYLVANIA
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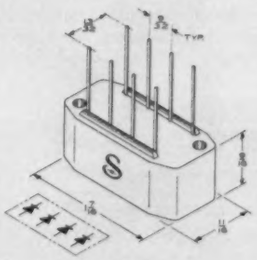
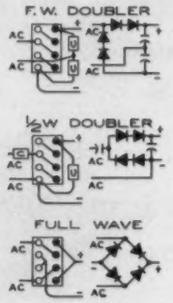
CIRCLE 30 ON READER-SERVICE CARD

Versatile Diode Assembly

New Vari-stack, consisting of four specially selected diodes mounted and embedded in Stan-Seal, is provided in six different current and voltage combination ratings. Diode stacks rated at 0.3 amp per diode are available in





VARI-STACK Diode Assembly (left) is shown connected in three of many possible rectifier configurations.

PIV ratings of 100, 200 and 360 volts, and 1.0 amp diode assemblies are available at 100, 200 and 400 volts PIV.

The terminals of each diode are available for connection, enabling twelve or more different rectifier combinations from each assembly. Half-wave doubler, full-wave bridge and full-wave doubler configurations are shown in the illustration. Maximum input voltage should not exceed .701 of PIV for resistive load, or .35 PIV for capacitive load . . . (*From 48-page catalog No. 661-2, Standard Rectifier Corp., 620 East Dyer Rd., Santa Ana, Calif.*)

FOR THIS LITERATURE CIRCLE 107 ON READER-SERVICE CARD

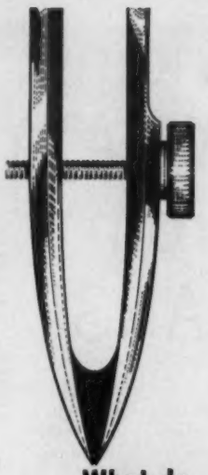
Rectilinear Pot is Titan Actuator

The Humphrey Model RP14-0602-2 pictured, qualified for use in TITAN missile control actuators, is typical of the precision potentiometer designs available for use in high performance control and instrumentation systems and both ac and dc applications.

The resistance elements and rails are bonded to the base with high dielectric strength and temperature resistant silicone varnish.

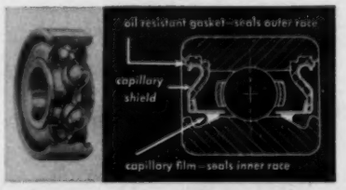
Specifications for the RP14-0602-2 include: Electrical noise, 100 ohms at velocities to 10 ips; insulation resistance, 50 megohms at 500 v dc any terminal to case; temperature range —35° to 275° F; vibration, 25 G at 28 to 2000 cps; Shock, 100G; weight 5 oz. Element No. 1 is 10,000 ohms ± 10%, 0.25 watts; element No. 2 is 1000 ohms ± 10% at 2 watts. Both elements have linearity of 0.5% and resolution to 0.1%. Electrical travel is 2.130" . . . (*From new 28-page catalog "Precision Potentiometers", Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.*)

FOR MORE INFORMATION CIRCLE 108 ON READER-SERVICE CARD



What do Bow Pens have to do with Miniature Bearings?

They help us illustrate the principle behind our famous RMB Filmoseal construction. The ink in a bow pen is held in place by capillary action—so is the oil that forms the seal in the Filmoseal bearing. This means sealing is accomplished with no rubbing mechanical contact between rotating and stationary members.
Here's how it looks:



The advantages are obvious:

A SEALED BEARING WITH—
NO RUBBING FRICTION
NO INCREASE IN TORQUE

You can specify RMB Filmoseal bearings to *low cost* ABEC 1, or 5 or 7 tolerances. Sizes available range from .1875" OD/.0550" Bore to .8661" OD/.3150" Bore. Immediate delivery. Write for complete data.

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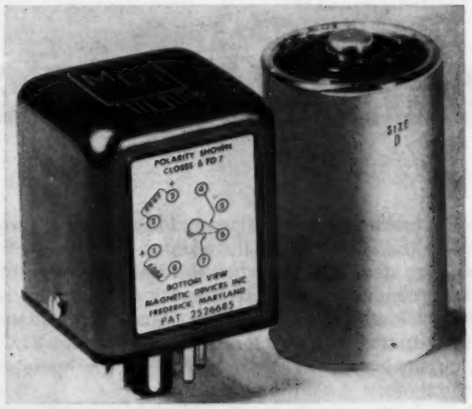
45 West 45th St.
New York 36, N. Y.

CIRCLE 31 ON READER-SERVICE CARD

Military Polarized Relays

MDI Polarized Relays (Fig. 1) are designed to meet the environmental conditions of Specification MIL-E-16400 for humidity, temperature cycling and cold storage tests. Satisfactory operation may be obtained from —60° to 85°C. Operational characteristics under shock and vibration conditions vary with armature adjustment and coil current. Shock pulses up to 125 G and vibration up to 500 cps at 10 G cause no mechanical damage.

Contact arrangements are characterized by the terms "side-stable, spring-biased and center-off." A side-stable armature remains in its last energized position when coils are de-energized; armature transfers to the opposite side when coil is energized with proper polarity or remains in its position when coil is energized with opposite polarity.



MDI POLARIZED RELAY compares in size with a D size flashlight cell.

A spring-biased armature always closes the same pair of contacts when coils are de-energized; operation is similar to a non-polarized relay except that armature transfer depends on coil signal polarity.

A center-off armature remains in a neutral position with contacts open when coils are de-energized; armature transfers to one side or the other when the coil is energized.

MDI Relays are available with 1, 2, 3 or 4 coils, with more than one coil, the relay will operate on the differential of coil currents. This provides many versatile input arrangements. For example, if the outputs of each of four temperature sensing circuits are connected to a four-coil relay, the circuit may be adjusted to operate the relay when any one of the four temperatures exceeds a certain value, or by additive and subtractive combinations of these temperatures. . . (*From 6-page catalog F, Magnetic Devices, Inc., Dept. P., 712 East St., Frederick, Md.*)

CIRCLE 109 ON READER-SERVICE CARD

VECO PIONEERS NEW THERMISTOR FRONTIERS

It's mighty important to know if you're working on sub-zero human survival programs for the Armed Forces. That's why scientists tape VECO Thermistors to penguins ... even bury them in penguin eggs ... to record the precision temperature data on living cells that can save lives in Antarctic-type environments.

You may never have to Thermistorize a penguin, but when reliability counts, it's good to know you can count on VECO. Reliability is the reason engineers in every field specify VECO Thermistors and Varistors where precision thermal or electrical measurement and control are critical. They know their Thermistor and Varistor reliability programs begin at Victory. Unsurpassed quality control is the reason. Not one VECO product ever leaves the plant until it individually passes tests for reliability far exceeding applicable specifications. VECO quality control processes are accepted under MIL-Q-9858 standards.

FREE: If you want to control, measure, or use temperature for any project between the North and South poles, you'll find VECO's Thermistor-Varistor Catalog valuable in producing high-reliability circuitry.

VECO **VICTORY** ENGINEERING CORPORATION
130 Springfield Ave., Springfield, N. J.

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THERMISTOR CATHETERS AND NEEDLES • THERMAL CONDUCTIVITY CELLS
MATCHED THERMISTORS • THERMISTOR AND VARISTOR KITS
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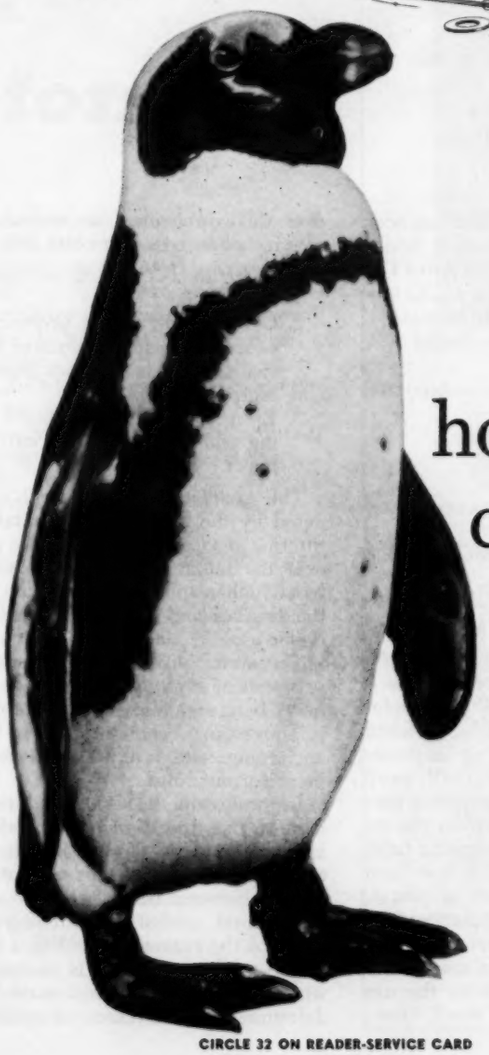


how cool is a penguin?

CIRCLE 32 ON READER-SERVICE CARD

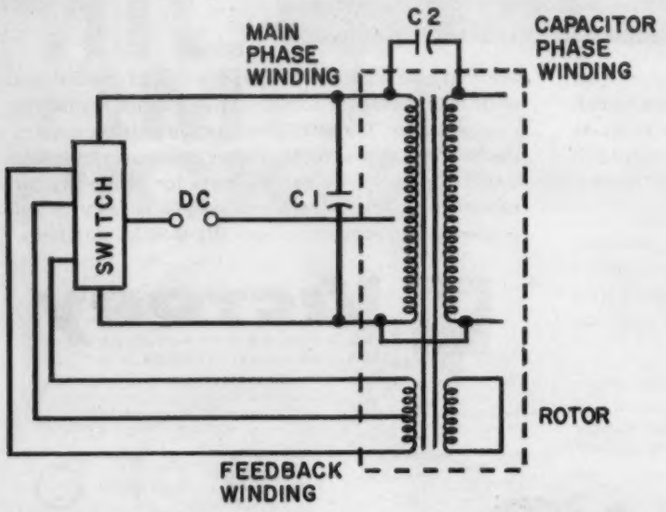


FIG. 1. TWO-PHASE BRUSHLESS DC Motor, basic circuit diagram.

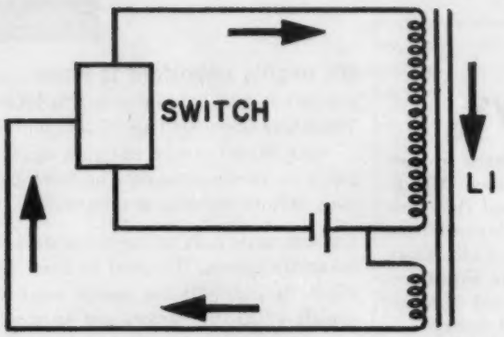


FIG. 2. SIMPLIFIED OSCILLATORY Loop indicating frequency determining elements in Brushless DC Motor.

Brushless DC

LEONHARD KATZ
Astro Dynamics, Inc.

The Brushless DC Motor is a device which has been desired by industry for many years. Such a device has been developed and is in production at Astro Dynamics, Inc., Burlington, Mass. The Brushless DC Motor has numerous advantages which are as follows:

1. Eliminates electrical noise when operating.
2. Eliminates acoustical noise.
3. Eliminates arcing problems that are encountered at high altitudes.
4. Eliminates the use of bulky ac supplies.
5. Reduced maintenance requirements.
6. Increases the longevity of the device.
7. Displays a wide variation of speed control characteristics.
8. Retains the simplicity of an ac device.
9. Increases reliability.

Principles of the Brushless DC Motor

There is, of course, no such thing as a true dc motor. All "dc" motors in essence are "ac" motors because a rotating field must be established inside the motor as the shaft revolves. The windings must be switched in such a manner that each winding, as it passes through the established magnetic field, will carry current in the proper direction so as to provide a continuous electromagnetic torque resulting from the interaction of the current carrier and the magnetic field. The most popular switching device which has been employed for many decades in dc/motors, of course, has been the commutator and brush combination. The use of commutators and brushes has certain advantages since its contact resistance can be made very low and therefore the losses resulting from the use of such a device can be kept extremely small. However, this arrangement has several basic disadvantages of which the most important are as follows:

1. Short life because of mechanical wear and rubbing action.
2. Considerable arcing problems encountered because of the high inductive load which must be switched. This becomes especially important at high altitudes.
3. Electrical noise is generated because of the arcing and interruption of current in the commutators.

The generation of electrical noise can be eliminated by the installation of suitable suppressors and filtering devices, however bulky they may be. However, the limitations in life of brush machines, especially at higher speeds, are difficult to overcome since the brushes and the commutators will wear rapidly under use.

The arcing problem at high altitudes and in environments of explosive or corrosive fumes or gasses has never been solved except by confining the motor within a pressurized enclosure and so keeping the brushes and commutators physically isolated from the ambient surroundings.

In the Brushless DC Motor developed by Astro Dynamics, Inc., the commutator and brush combination has been totally eliminated. The motor winding is center-tapped so that the current is permitted to alternate between the two halves of the winding, and an external solid-state switching device is used instead of the commutator (Fig. 1).

The solid state switch is controlled by a feed-back winding which generates a control voltage which also determines the frequency of operation of the device. Several additional resistors are added in order to properly set the bias level of the various elements in the switching device and to get the unit started. Anti-spiking condensers are used across the windings to reduce voltage peaks and also to adjust the impedance of the winding so that the resonance frequency of the LC circuit is near the desired frequency for operation of the motor.

In order to provide starting characteristics for this motor it is usually necessary to have a second winding called the "capacitor phase winding". In this second winding, a phase lag is introduced by means of a capacitor and the winding is physically displaced from the main phase winding so as to provide a shifting field for motor starting.

Major problems involved in design of the switching device are:

1. The power handling capacity of the switching device must be sufficient to handle the peak voltage and currents.
2. The impedance match of the switching device and the windings must be reasonable, both for starting and running operations.
3. The frequency of the entire system must be chosen properly.

The first two are easily overcome because this involves only the proper choice of components and the calculation of the impedance of the windings which can be varied by proper selection of magnetic core and conductor size considerations. However, the new variable which is introduced in this type of motor is the frequency of oscillation. If we examine Fig. 1, we will see that the frequency of the entire device is determined by the delay time around the loop. This

loop contains a switching device, a winding in the motor, magnetic coupling to the feed back winding, and a return of the feed back winding to the switching device. The overall frequency will essentially be determined by: (a) Transit time in the switching device, and (b) transit time in the magnetic loop.

The determination of the frequency primarily is governed by the magnetic properties of the motor which must be considered in greater detail. A simplified diagram of the oscillator loop is shown in Fig. 2. Essentially, we have a primary winding to which a certain voltage is applied suddenly. Current begins to flow which causes a change in the magnetic field. The delay between the growth of the magnetic field and the application of the voltage is, of course, determined by the inductance of the motor. Similarly, a change in magnetic flux in the core of the motor introduces an emf in the secondary winding, which in this case is the feed-back winding. There is again a delay, depending on the amount of current generated, which is extremely small because the feed-back winding acts essentially as an open circuit winding.

Although the principal frequency determining element is the inductance of the motor, this is not constant because the rotor is also in the magnetic circuit. This introduces a variable reluctance determined by the air gap between the rotor and the stator, the speed at which the rotor is running, and the load which is applied to the rotor. The condition of the rotor thus exerts an effect on the frequency of the oscillator, which in turn affects the performance of the motor unless certain corrective measures are taken. In most conventional motors, the corrective action, (brush shifting, etc.) is fixed by the motor structure and it cannot be varied much. In our case, however, the "corrective measures" can be changed at will to provide any desired characteristic because in the feed-back loop we have voltages in the range of approximately 2 to 10 volts at negligible currents. Consequently, large scale effects can be obtained by operating on this low-powered feed-back portion of the oscillator loop.

By varying the control mechanisms, the following types of motors have been obtained:

a. A motor in which the speed remains constant with an accuracy of 0.5% over a voltage range from 10-40 volts dc. This provides a motor in which the frequency is independent of dc voltage and gives what is normally known as "ac characteristics."

b. A motor in which the speed is directly proportional to input voltage from 10-40 volts dc. This produces what is normally known as "series dc motor characteristics."

c. A ½-hp motor, in which the speed can be controlled from 2000 to 14,000 rpm by means of a small miniature potentiometer.

d. A motor in which the speed is inversely proportional to temperature. This motor speeds up as the temperature increases and slows down as the temperature decreases. No external controllers or amplifiers are used.

e. A motor which starts slowly to eliminate current surges. This motor—without external controls—takes two minutes to come to full speed, thereafter it has conventional characteristics.

f. A motor which has high speed starting characteristics and starts almost instantaneously. After reaching running speed, it has conventional characteristics.

The foregoing list does not exhaust the possibilities of the new device. By the introduction of various networks and low-voltage elements we can provide new types of characteristics which have heretofore never been obtainable, except by means of very complex controllers. For instance, we can provide speed-torque characteristics in which the torque is inversely proportional to speed, directly proportional to speed, or is independent of speed, and these characteristics can be obtained in the same motor by means of a three-way switch. Similarly, the characteristics can be made a function of temperature, barometric pressure or external inputs at low voltage and negligible current.

Fundamentally what we have obtained here is a motor in which a new variable has been introduced; i.e., frequency. Furthermore, the frequency of the motor is controllable by low-voltage devices—by variation of small components.

and Universal Motors

Application of the Brushless DC Motor to Fans

As a result of the development work done at Astro Dynamics, Inc. in the development of the Brushless DC Motor, logical application of this principle was seen in fans and blowers for the cooling of electronic devices. Three types of fans for comparison with existing devices were developed as follows:

1. *Model* 3201 *Fan.* This is a small fan with a fan blade of 4" in diameter (Fig. 3A). The overall dimensions of the fan are 4-11/16 x 4-11/16 x 1-3/4" and its weight is 1-3/4 lbs. The fan can operate over a range from 10 to 40 volts dc with performance characteristics as shown in Fig. 4. The speed of the fan is almost directly proportional to applied voltage, also, the current consumption is directly proportional to applied voltage over that range. A typical air performance curve at 28 volts dc is given in Fig. 5, giving 100 cfm at zero pressure.

The Model 3201 fan uses a simple type motor with only two windings. The frequency of oscillation at 28

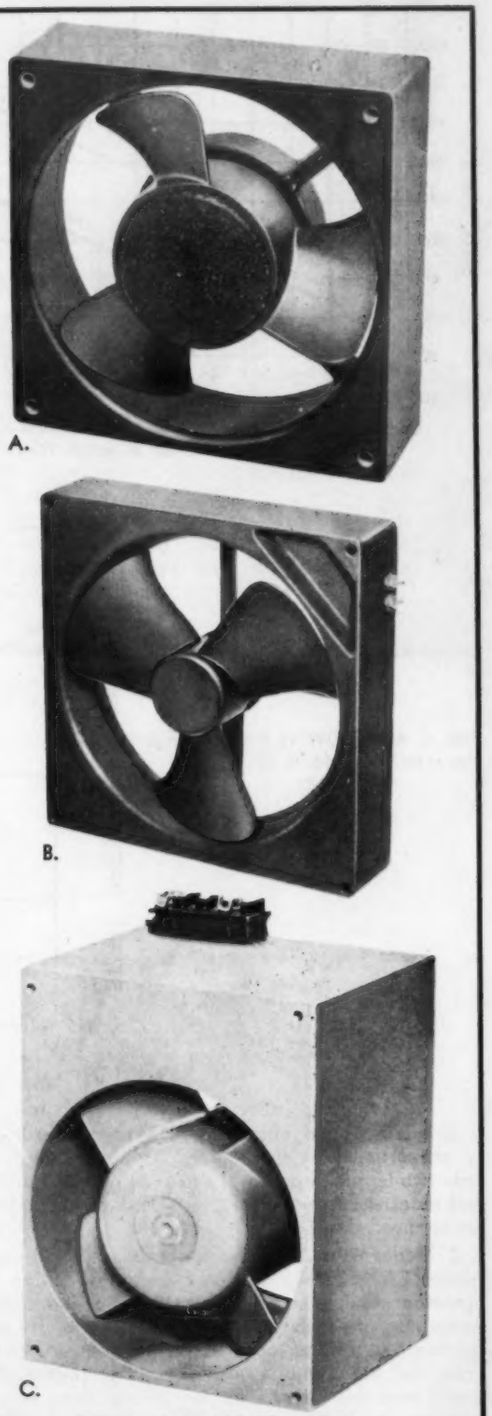


FIG. 3. FAN APPLICATIONS of 28 v dc Brushless Motors (A) Model 3201—100 CFM, (B) Model 3301 —170 CFM, and (C) Model 3401 —18000 rpm, 150 CFM.

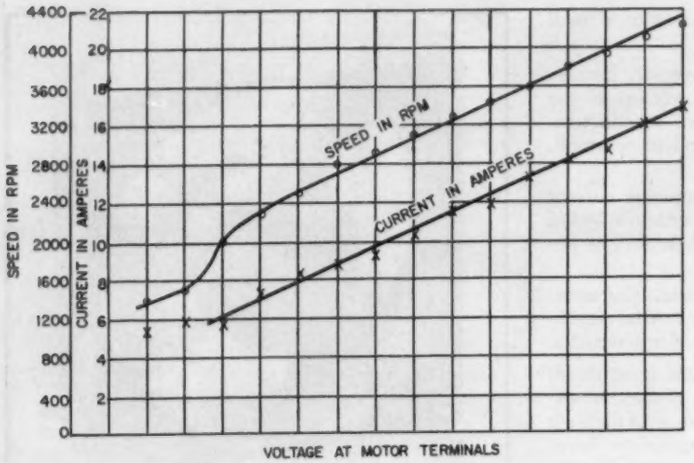


FIG. 4. ELECTRICAL CHARACTERISTICS, Model 3201 Brushless DC Fan.

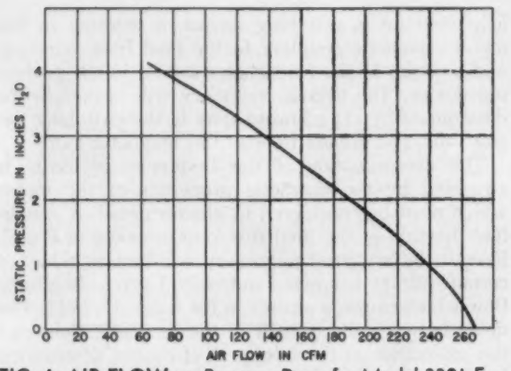


FIG. 6. AIR FLOW vs. Pressure Drop for Model 3301 Fan.

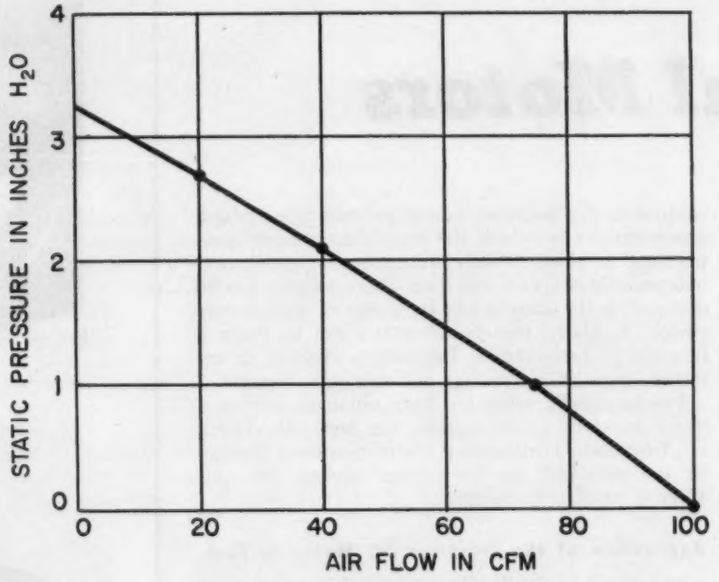


FIG. 5. AIR FLOW vs Pressure Drop characteristics, Model 3201 Fan.

v dc is 120 cps and, of course, the frequency is directly proportional to the applied voltage. There are only two terminals on the fan marked plus and minus, and no external components such as starting condensers are needed.

2. *Model* 3301 *Fan.* This fan (Fig. 3-B) drives a blade of 7" diameter and is a brushless dc fan for operation under higher air delivery requirements. Again, the speed of this motor is almost directly proportional to voltage over the range from 10 to 40 volts, and the current is also directly proportional to speed over this range. This motor uses three sets of windings, including a capacitor phase winding. All the components including the phase lag capacitor are contained in the housing of the fan. Two terminals are provided marked plus or minus on the unit. The right-hand upper chamber is left empty as shown, but is occupied by diode-capacitor elements when this motor is used as a universal motor for operation on either dc or variable-frequency ac from 25 to 2000 cycles. The air flow characteristics are shown in Fig. 6.

3. *Model* 3401 *Fan.* This is a small blower with an impeller diameter of 3" for operation at very high speeds (Fig. 3-C). Two models are available. Model 3401A is designed to operate at 10,500 rpm at 28 v dc; and Model 3401B at 18,000 rpm at 28 v dc. These changes are obtained by a slight variation of the windings and feed-back circuitry. The characteristics of the motor are shown in Fig. 7. This motor uses a main phase winding and a capacitor phase for starting. The weight of the motor is 1-1/4 lbs, and its dimensions are 3 x 3-3/4 x 3-1/2". The air flow characteristics of the Model 3401B are also shown in Fig. 7.

High Voltage Motors

As a result of additional work done at Astro Dynamics, Inc., a significant breakthrough in development now permits the use of this motor at much higher voltages and at very much higher power levels. As a result, we are making motors to operate from 110 volts ac or dc directly at power levels up to 20 hp. A corollary of this recent development has been that the motor has now become a universal type which can operate from either ac or dc from the same terminals and whose speed and power characteristics are totally independent of frequency over a range from 25 to 2,000 cycles.

This is done by first converting the ac to dc and then utilizing the Brushless DC circuit. This provides an extremely compact unit since the use of "transformerless dc supply" requires only the addition of a diode and a condenser. The only limitation of this circuit is that at frequencies less than 25 cycles, the condenser tends to become very large.

A truly universal motor having a multitude of desired characteristics, depending on how windings and feedback networks are arranged, now appears practicable.

FOR MORE INFORMATION CIRCLE 470 ON READER-SERVICE CARD

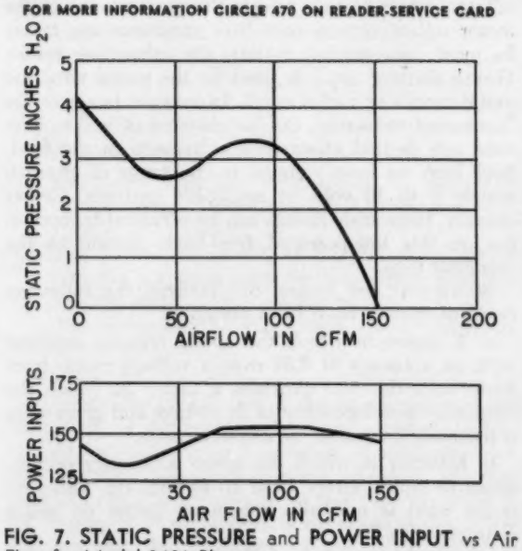
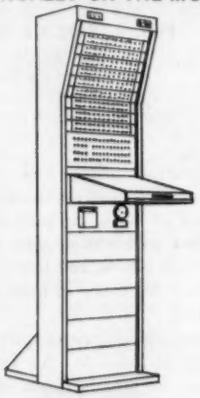


FIG. 7. STATIC PRESSURE and **POWER INPUT** vs Air Flow for Model 3401 Blower.

SILTRONICS, INC.

CONTINUALLY ON THE MOVE...



SCOPE

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Communications and electronics systems, subsystems and components incorporating modular construction, solid state and/or vacuum tube circuitry and printed wiring . . . precision electromechanical devices . . . shock and vibration mountings.

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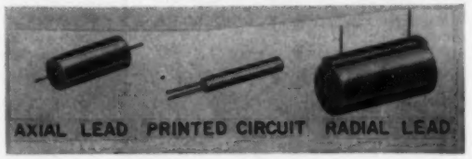
CIRCLE 33 ON READER-SERVICE CARD

Encapsulated Precision Wirewound Resistors

Standard, subminiature and microminiature sizes of precision wirewound resistors, said to have the highest wattage rating per physical size, are available in the three encapsulated styles shown below from the HanJohn Co., Inc., of South El Monte, Calif.

Resistors wound from different materials are available to supply specific temperature coefficient characteristics desired by the user. Standard temperature coefficient of resistance of materials, designated as "F" in the table below, is zero ± 20 ppm/° C in any resistance above 100 ohms in the temperature range —65° C to 125° C. Other temperature coefficients listed



are available on special order. For resistors below 100 ohms, aged nickel-chrome resistance wire is used for "F" temperature coefficient resistors, and are available on special order, Maximum ambient temperature of HanJohn resistors at 145° C at rated load, derating to zero at 165° C.

TEMPERATURE COEFFICIENT SYMBOLS

TC SYMBOL	WIRE	RESISTANCE TC OF WIRE
F	Evanohm/Karma (from 100 ohms up)	±*15 ppm/°C
F¹	Manganin (below 100 ohms)	±20 ppm/°C
F	Evanohm/Karma (10Ω-99.999Ω)	±30 ppm/°C
O	Nichrome/Tophet C	130 ppm/°C
B	Nichrome V/Tophet A	100 ppm/°C
Z	Hytemco/Balco	4500 ppm/°C
L	Copper	390 ppm/°C
M	Nichel	4800 ppm/°C
N	Manganin	*15 ppm/°C
D	Cupron/Advance	30 ppm°/C

*TC between +15°C and +35°C

Extremely low-value resistors and associated circuitry should be used with caution, because the copper wire in the circuit often affects the apparent temperature coefficient to a greater degree than a specific resistor.

The HanJohn precision resistors are encapsulated with glass epoxy. No asbestos is used in the impregnation, hence no abrasive action. All units are vacuum impregnated and temperature cycled to remove the strains set up in the wire during winding which would otherwise affect the temperature co-efficient adversely. This also produces a resistor which is drift-free, equivalent in stability to several years of aging . . . (*From 4-page catalog of Military type resistors, The HanJohn Company, Inc., 9834 East Alpaca St., South El Monte, Calif.*)

FOR THIS LITERATURE CIRCLE 110 ON READER-SERVICE CARD

SHOWN ACTUAL SIZE

SIZE 5 COMPONENTS

FOR SERVO SYSTEM MINIATURIZATION

A complete family of Size 5 components for every servo system function is now available from Kearfott. Stainless steel housings, shafts and bearings protect the units against environmental extremes and contribute to stability under shock, vibration, and temperature fluctuations. • Standard 26-v, 400-cps excitation. • Operating temperature range —55° to +125°C.

CHARACTERISTICS

SYNCHROS

	VOLTAGE (400 cps)	T.R.	NULL (mv)	ERROR (min)
Transmitter CJO 0565 100	26	.454	34	10
Control Transformer				
Low Z-CJO 0555 100	11.8	1.765	34	10
High Z-CJO 0552 900	11.8	1.765	34	10
Differential CJO 0595 100	11.8	1.154	34	10
Resolver				
Low Z-CJO 0585 100	26	1.0	34	10
High Z-CJO 0589 100	26	1.0	34	10

SERVO MOTORS

	J126-06	J126-02
No-Load Speed	9800 rpm	9800 rpm
Stall Torque	0.10 in. oz	0.10 in. oz
Rotor Moment of Inertia	0.175 gm cm²	0.175 gm cm²
Voltage φ1 / φ2 (400 cps)	26 / 36-CT	26 / 26
Power Input / Phase	1.7 w	1.7 w

SYNCHRONOUS MOTOR

	CJO 0172 200
Pull-In Torque	0.06 in. oz
Pull-Out Torque	0.10 in. oz
Pull-Out Power	4 w

MOTOR GENERATORS

MOTOR	CJ40812001	CJ00812650	CJ00813200
Voltage φ1 / φ2 (400 cps)	26 / 36-CT	26 / 36-CT	26 / 26
Power / φ	1.5 w	1.5 w	1.5 w
No-Load Speed	8000 rpm	8000 rpm	8000 rpm
Stall Torque	0.10 in. oz	0.10 in. oz	0.10 in. oz
GENERATOR			
Voltage (400 cps)	26 v	26 v	26 v
Volts / 1000 RPM	0.1 v	0.1 v	0.5 v
Null	1.3 mv	10 mv	6.7 mv

Size 5 gearheads range in reduction ratios from 20:1 to 1019:1 for servomotors and motor tachometers above. In addition to Size 5 clutches, brakes, and brake-clutches, Size 6 are available.

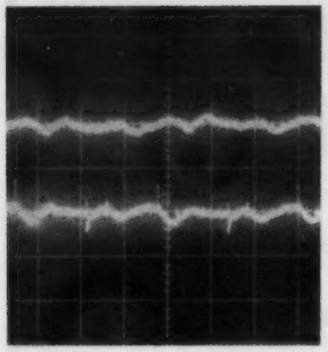
Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE 34 ON READER-SERVICE CARD

Power Reference Source



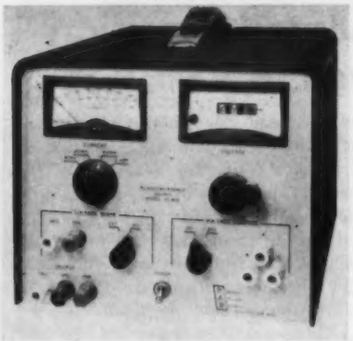


FIG. 1. VOLTAGE REFERENCE and precision power supply eliminates overshoots and ringing due to transients which endanger solid-state low voltage components.

FIG. 2. TYPICAL RIPPLE components. Upper trace at no load, lower tract at full load. Vertical scale 200 uv/cm; horizontal scale 5 msec/cm.

Designed as a precision 120-watt power supply for experimental applications, a new Model TC-602 unit (Fig. 1) provides highly regulated, continuously variable voltage to 60 volts with output current limited electronically to 80 ma, 200ma, 800ma and 2 ampere levels, selectable at the will of the operator.

The power supply utilizes a unique chopper stabilized amplifier with a dc open loop gain of 5×10^6 falling off no faster than 6 db per octave to unity gain. This insures extremely low output impedance (less than 10 μohms at 0 cps to 1 ohm at 1 mc) and fast transient response without ringing. Non-dc components in the output (ripple, hum, noise and spikes) are maintained below 50 μvolts rms under all load conditions (Fig. 2). Momentary main power failures and normal turn-on, turn-off cause no voltage overshoots or ringing thus providing protection to low voltage devices in the test circuits.

Prolonged short circuit operation will not damage the supply and normal output voltage is restored automatically upon removal of the load fault. This feature is useful in certain critical experiments where momentary shorts may occur without causing complete system shutdown.

Voltage and temperature stability is obtained by using temperature controlled and temperature stabilized reference and low temperature coefficient resistors. The error signal is derived from a true potentiometer circuit in which slide-wire currents are kept in the milli-microampere range, avoiding noise problems usually associated with slide wire potentiometers. Eight-hour stability under full load at full voltage in an uncontrolled ambient temperature and operating on an unregulated supply line, is shown in Fig. 3 . . . (*From 4-page technical bulletin* 101, *Princeton Applied Research Corp., P. O. Box* 565, *Princeton, N. J.*)

FOR MORE INFORMATION CIRCLE 111 ON READER-SERVICE CARD

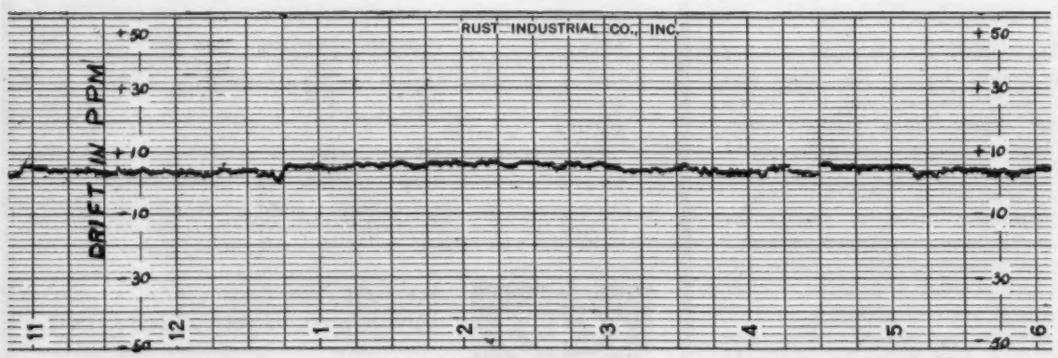


FIG. 3. EIGHT-HOUR stability under full load at uncontrolled room temperatures and unregulated line. Vertical scale: 10ppm/major division.

Pocket-Size Laboratory Standard

FIG. 1. POCKETPOT is a true potentiometer, gives infinite impedance readings at balance to accuracy of .05% over 0-5.100 v dc range.

The new Model PC Pocketpot (Fig. 1) is a miniaturized DC Potentiometer for use over the basic range of 0 to 5.100 v to an accuracy of .05%. A "plug-in" switch-controlled Current-Volt Box of identical size and shape extends its voltage range to 0-500 v, and permits current measurements to 0-1 ampere. Accuracy of both units used together is 0.1% over all.

The Pocketpot is a true potentiometer providing infinite impedance readings at balance. As in all such potentiometers, a current is standardized through a chain of resistors, R1 and R2, (Fig. 2), to provide a known voltage drop which is compared to the external voltage by a high sensitivity detector.

Indication of zero on the "null" meter shows equality between the internal and external voltages. The value of

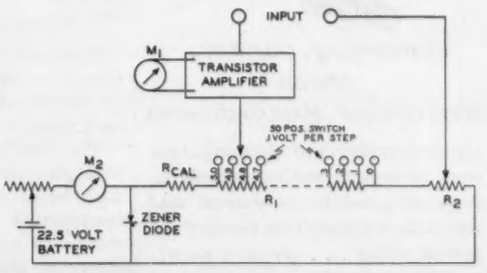


FIG. 2. METHOD of balancing zener voltage against voltage divider circuit prevents "loading" of unknown potential source.

the external voltage is then read directly from the settings of the resistor switch. A transistor amplifier

is used to drive a small but rugged null indicator, which gives a sensitivity in excess of 0.1 millivolt.

Current in the potentiometer is standardized by a zero temperature coefficient zener diode. The same meter which is used as the null indicator is switched into the zener diode network at M2 to measure the current applied to the zener network. Because the zener diode used has an extremely steep characteristic, adjustment of the operating current to within 1% allows the operating voltage of the zener to be determined to better than 0.01%. The 22½v battery can be used until it has dropped to approximately 15 v without affecting the accuracy of the measurements.

To operate, the instrument is energized by turning the righthand toggle switch "on" and the left toggle switch is set on "check current" position. Adjustment of the current control knob until the meter needle is at the right hand limit of the scale standardizes the zener diode and potentiometer network current.

The left hand toggle is then switched to the "read" position. With the unknown voltage applied to the terminals, rotate the two voltage dials until the meter needle, reading as a null detector, rests on the zero mark. The exact voltage is then read directly from the in-line dials. In Fig. 1 the reading of 3.911 volts is indicated.

The Pocketpot is particularly valuable in measuring corrosion potentials. Errors most frequently encountered in corrosion measurements arise from the fact that previously available portable sensitive voltmeters consume some current. Although small, in high resistance cor-

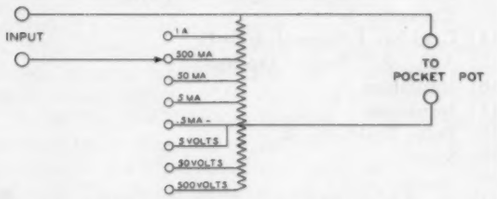


FIG. 3. RANGE EXTENDER enables measurement of currents to 1 amp, potentials to 500v dc, with accuracies of .1% needed in field maintenance.

rosion paths this current 'flow upsets the potentials normally prevailing. With the range extension unit (Fig. 3) added, the Pocketpot covers the output voltages of most cathodic protection devices, to eliminate the need for a separate meter for maintenance . . . (*From 4-page Bulletin "Electrical Measurements" 28/7, Sensitive Research Instrument Corporation, 310 Main St., New Rochelle, N. Y.*)

CIRCLE 112 ON READER-SERVICE CARD

SOLID-STATE DEVELOPMENTS

including New Microcircuits, Thin Films and Power Transistors are emphasized in the **January-February 1962** issue of **Military Systems Design.** Advertisers have 'til **January 10** to order space.

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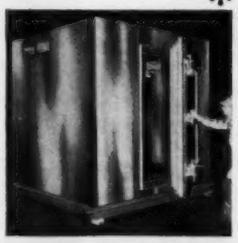

MAGNETIC SHIELD DIVISION
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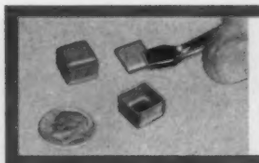
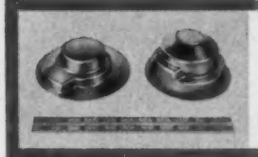
ORIGINATORS OF PERMANENTLY EFFECTIVE NETIC CO-NETIC MAGNETIC SHIELDING

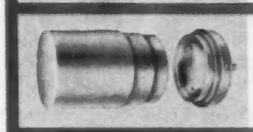

Micro miniature shield and cover, punch press operation.

Sequence of shield cans, punch press or spinning.

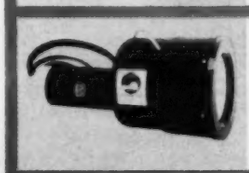

Complex configuration multi-lamina shield, hydroformed.

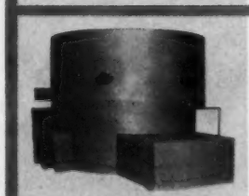
CRT shield illustrating combination of hand fabrication, spinning and sizing.

Backward wave tube shield assembly design, involving hand fabrication and hydroform or spinning.


Special purpose shield, hand fabrication (levitated gyro).

Tape preserver can be spun, hydroformed or punch press fabricated.


Data storage tube shield, hydroform or spinning, plus hand fabrication.


Large fabricated special structure (shaker table shield), approx. 60" dia. and 57" high.

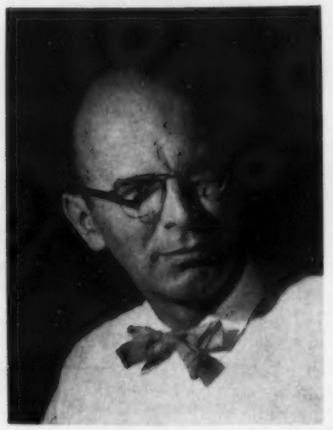
Composite photo demonstrating that magnetic shielding qualities of NETIC alloy material are not affected by vibration, shock, (including dropping), etc.

CIRCLE 35 ON READER-SERVICE CARD

FIG. 1. AUTOMATIC ELECTRON TUBE TEST SET requires only two operators to maintain a continuous test rate up to 1500 Mil-Spec tubes per hour. Operator at right is loading the tube holders which move automatically through six- pre-test heater positions to twenty test positions. Workers at left boxes accepted tubes, while satistical worker in background records test data figures.

by NORMAN WEEKS,

AUTHOR of this article and designer of the tube testing system discussed therein is the Manager, Test Equipment and Standards, Industrial Components Div., Raytheon Co.



Multiple Testing of

AUTOMATED TUBE TESTING, accomplished by a new seven-ton robot designed and developed by the Raytheon Company, Newton, Mass., is credited not only with accelerated testing rates but with higher product reliability and a new order of quality control over the tube manufacturing operation.

Three employees attend the machine, one manually loading the tube holders, while a second worker sorts tested tubes into bins. A third worker performs statistical analysis work, a function which could be performed by a small computer. Maximum capacity for the machine is 1850 Mil-Spec tubes per hour.

The tester not only operates at rates up to six times faster (two operators now test 1500 tubes per hour as compared with a manual test output of 250 tubes per hour from three employees), but the test results are more consistent. Field rejects have decreased sharply since the new machine became operable. Previously, human fatigue and boredom entered into the picture, lowering the quality assurance factor. The machine, on the other hand, gives the same reliability performance in afternoon production runs as in morning runs—day in, day out. As a result of this performance repeatability, every tube is subject to exactly the same test conditions at all times.

The automatic test set is designed to test each tube to conform with the electrical test specifications for its type. Periodic checking by the quality assurance section indicates that the automatic test set meets acceptance qualification limits specified for reliable tubes practically 100% of the time.

Quietly operating in an air conditioned atmosphere, the 14,000-lb machine performs the following tests in any sequence after the first three:

1) Shorts (tap test)
2) Filament Current, If
3) Continuity (tap test)
4) Plate Current Cut-off, Ibco
5) Plate Current, Ib Hi
6) Plate current, Ib Lo
7) Plate current difference, Δ Ib
8) Transconductance or voltage gain, Sm or VG-Hi
9) Transconductance or voltage gain, Sm or VG-Lo
10) Grid No. 2 Current, Ic2—Hi, Lo
11) Heater-Cathode Leakage, ± IHK
12) Heater-Cathode Leakage, ± IHK
13) Emission, Is
14) Grid No. 1 Current, Icl—Hi
15) A.F.—R.F. Noise (tap test)
16) Insulation
17) Insulation
18) Pulse Emission, Ik
19) Spare
20) Spare
21) Good Tube Eject

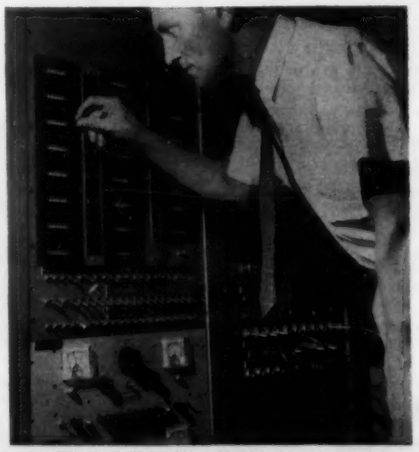


FIG. 2. DATA ACCUMULATION Panel. Engineer is resetting incoming tube digital counter. Other counters show numbers of tubes rejected at each test position and total number of tubes passing all tests.

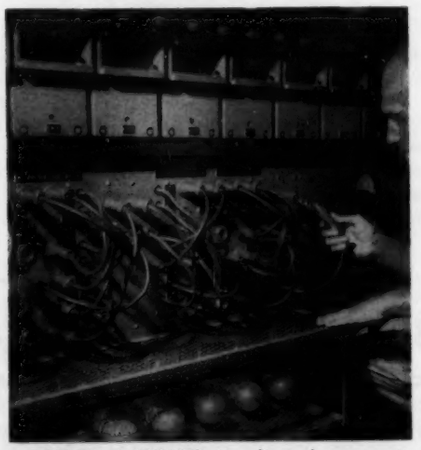


FIG. 3. PREHEAT POWER is adjusted preparatory for tests on a new type of tube. Patch panels give complete flexibility to cover future as well as all present heater current requirements.

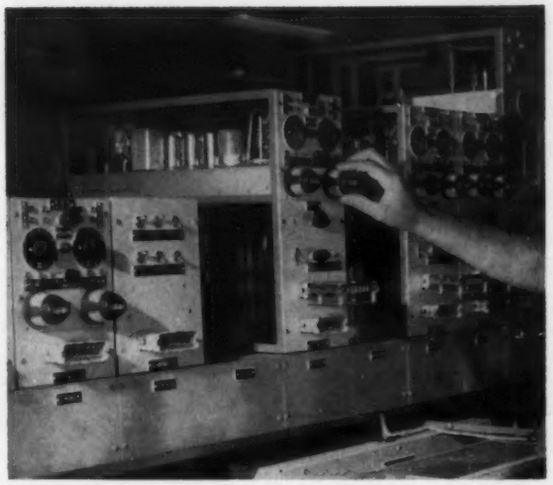


FIG. 5. DUAL CHANNEL COMPARATOR or "null detector" is heart of flexible test module, each channel comparing an unknown dc voltage to a known reference, which the engineer is adjusting visually. An input range switch inserts a precision resistor in series with the tube element drawing current, thereby creating a voltage to compare with the reference.

Electron Tubes—Automatically

A digital counter for each test position indicates the number of rejects per position as well as the total input and output. Each test position is independent of the others, which allows complete flexibility in applying voltages and allows special tests wherever needed. This flexibility also enables the machine to keep abreast of new types of tubes or to test the same tubes to more stringent MIL-Specs at any future date.

One of the first decisions reached in the design of the new tester was that an exceptionally reliable indexing unit was necessary. Purchase of an Auto Trans Indexing Unit as the basic unit on which the various test and operating features could be added speeded the development of the system. The Auto Trans unit was stripped down and modified to house tube holders, pre-heat supplies and controls (including patch and lamp panel), a master cam switch and other equipment (Fig. 1). Interconnecting with the unit is a "control center" console.

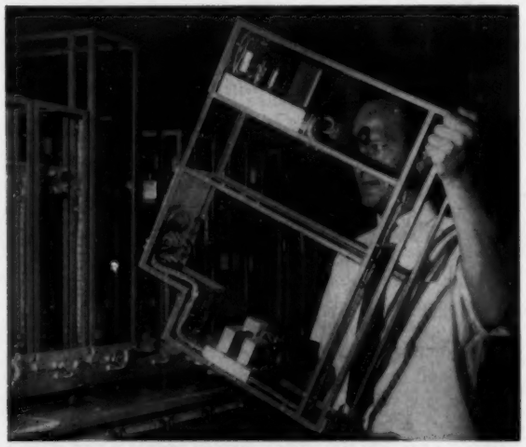


FIG. 4. TEST POSITION SEQUENCE, after the first three positions (short tap test, filament current and continuity tap test) can be altered at will by changing plug-in test unit modules. Alternate modules for each test also simplify maintenance, ensure against machine down-time.

Operation is simple. The loading operator continuously inserts a supply of tubes into tube holder sockets. As the machine indexes it carries tubes into the first of six power pre-heat sections where voltages are first applied. Then follows indexing into the first of the twenty test positions previously named.

At each test position, if the tube tests *within* preset limits, the tubes progress to the next position. If *outside* these limits, the tubes are ejected into appropriate reject bins. Rejects are automatically indicated on a counter (Fig. 2) for that particular test and the reject bins are segregated by fault classification. Tubes which pass all prescribed tests are also counted and ejected into the final or acceptance bin.

Quality control results are immediately fed back to tube type engineers concerned with the mechanics of production. The value of the test machine, from this standpoint, cannot be overemphasized. The machine closes the gap between test and production and prevents runs of thousands of tubes which may not be up to standard in all respects. During this time the data accumulation panel comes into play, providing a continuous presentation of tube type parameters and instant analyses of deviations which could precede the production of sub-standard tubes.

The following quality assurance procedures ensure the quality of the tubes passing the automatic test: (1) The automatic test set is calibrated daily and before "changeover" to a different tube type; (2) a sample of 25 tubes called "acceptable" by the automatic test set is withdrawn five times daily for laboratory tests. The tubes representing the sample are held until the sample is approved and are re-tested if the sample fails. (3) Quality Control "x" and "r" graphs are plotted hourly for up to 20 reject items for the acceptable tubes; and (4) a quality assurance sample is selected at the completion of each lot and submitted to tightened inspection per MIL-STD-105B.

FIG. 6. TAPPING MECHANISMS used during short and continuity tests are Teflon-tipped to impart a uniform, realistic shock to tubes. In the short test, tube elements are wired to taps in a series resistor string in a thyratron bias circuit. If elements touch, the thyratron grid is made more positive and fires, actuating the tube reject solenoid.

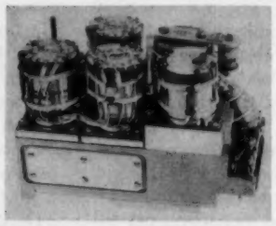
MSD new products

GUIDANCE TEST STAND

New test stand for integrated checkout of autopilot, compass and flight director system of the Convair 990 Astrojet simulates all inputs to guidance system required in actual flight, including localizer, VOR, glide-scope and OMNI.—*Seiscor Div. of Seismograph Service Corporation, P.O. Box* 1590, *Tulsa, Oklahoma.*

CIRCLE 116 ON READER-SERVICE CARD

SERVOMECHANISM PACKAGES



Improved line of semi-standard servomechanism packages results from use of easily adjustable damping networks with standard servo elements to meet the dynamic response specifications of specific applications including qualifications to military specifications.—*Superior Manufacturing & Inst. Corp.*, 36-07 20*th Ave., Long Island City* 5, *N. Y.*

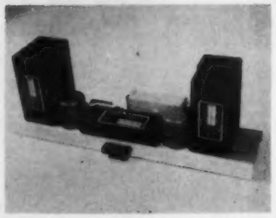
CIRCLE 117 ON READER-SERVICE CARD

LINEAR ACCELEROMETER

New Model AK 106 piezoelectric accelerometer with weight of 4.5 grams features natural frequency of 60 kc and operation over a range of ±10,000G. Sensitivity is 5 peak mv/peak G over temperatures from −65° to 250°F.—*Statham Instruments, Inc.*, 12401 *W. Olympic Blvd., Los Angeles* 64, *Calif.*

CIRCLE 118 ON READER-SERVICE CARD

GYRO POWER SUPPLY



New 3-phase, 400 cps gyro supply unit contains its own voltage regulation system to deliver 30 v rms with an accuracy of ±1%, at 1.5 amps max. A tuning fork keeps the frequency accurate to ±0.01% at 400 cycles.—*M. Ten Bosch, Inc.*, 80 *Wheeler Ave., Pleasantville, N. Y.*

CIRCLE 119 ON READER-SERVICE CARD

STURDY COIL BOBBIN

Laminated glass-cloth coil bobbin for gyro-erection solenoid by Bendix is fabricated by lay-up of silicone-impregnated glass cloth then laminating the preform under controlled heat and pressure in a matched metal mold. High mechanical strength, the thin wall required and Class "H" insulation properties dictated selection of materials.—*Silicone Insulation, Inc.*, 1383 *Seabury Ave., Bronx* 61, *N. Y.*

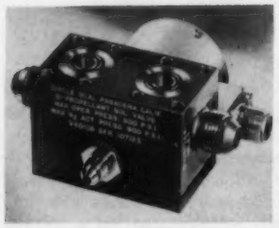
CIRCLE 120 ON READER-SERVICE CARD

SERVOVALVE DRIVE UNIT

New Transistorized Servovalve drive for air and missile ground equipment servos provides oscillator and amplifier for ac transducers, drives servovalves with dual 1000-ohm, 8 ma coils. Modular construction provides application flexibility at low cost.—*Raymond Atchley Div., American Brake Shoe Co.*, 2339 *Cotner Ave., Los Angeles* 64, *Calif.*

CIRCLE 121 ON READER-SERVICE CARD

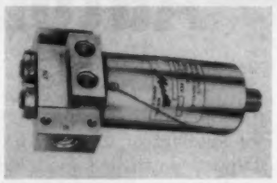
BI-PROPELLANT CONTROL VALVE



New fast-acting high-response valve for simultaneous control of fuel and oxidizer in space vehicle control systems act in less than 5 msec to full open or full close, and for operations up to 100 cycles per second. Deactivation of solenoids results in valve closure within ½ msec.—*James, Pond & Clark*, 2181 *E. Foothill Blvd., Pasadena, Calif.*

CIRCLE 122 ON READER-SERVICE CARD

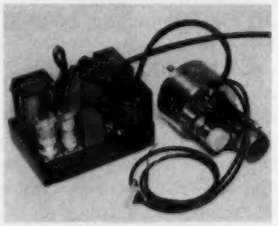
BI-PROPELLANT VALVE



Simultaneous opening of two liquid propellant lines (or cryogenics coolants) is assured by single 24-v dc solenoid actuation in new Model MV-194, 2-way, 2-position normally closed valve. Dual balanced poppets with teflon lip-type seals control fluids under pressure to 3000 psig.—*Marotta Valve Corp., Boonton, N. J.*

CIRCLE 123 ON READER-SERVICE CARD

DC INTEGRATING SERVO

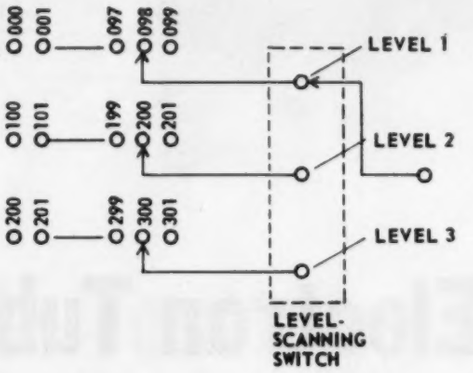


New Type CZ01714002 DC Integrating Servo provides an accurate integration of dc input voltage with respect to time as a function of shaft angle displacement. The integral-plus-proportional combination amplifier provides infinite gain causing no variation in output speed because of change in load, frequency and line voltage. Command signal is isolated with less than 30 μamp loading.—*Kearfott Div., General Precision, Inc.*, 1150 *McBride Ave., Little Falls, N. J.*

CIRCLE 124 ON READER-SERVICE CARD

Crossbar Scanning Techniques

A "scanning," "sampling" or "multiplexing" switch connects one or more of its poles to each of a set of contact positions in turn, in accordance with a fixed or controllable program. The program may be internally determined, generated and controlled; or it may be dictated (and/or varied) by an external programming device.



LEVEL SCANNING provides, in its longest cycle, automatic scanning of all channels in one level, followed by scanning of channels in the next level, etc., until all six levels have been scanned as one 600-point switch. Intermediate-length cycles provide two-pole 300-point scans or three simultaneous 200-point scans.

The basic Cunningham Crossbar Scanning module consists of a six-level, 10 x 10 crossbar switch mounted on a 7″ high standard 19″ rack panel. The complete assembly, 17″ deep, contains a regulated power supply with sufficient output for all standard accessories, and a logic chassis, containing the mercury-wetted relays and circuitry required to drive the switch and provide the standard command facilities.

This scanning system provides an almost unlimited number of programs, without rewiring, and upon external command. Many self-contained programs are available as simple, custom variations. In contrast with rotary motor driven scanners, in which the scanning rate is dictated by the internal requirements of the scanner, Cunningham Scanning switches can be slaved to external system signals (clock pulses, end-of-print signals, end-of-conversion signals, etc.) whether periodic or aperiodic.

The signals generated by a scanning device, and the manual and electrical instructions it is prepared to accept and use, are called its command facilities. Command facilities for a Standard Cunningham Crossbar Scanning System to provide almost any desired program and system synchronization may be achieved by appropriate combination of simple external circuitry and the basic command facilities. It is possible to skip over any designated group of channels and manually "reset" and "stop" selec-

or continuous scan, etc.

In many data-logging systems, it is necessary to identify the channel from which data is being taken, visually, electrically, or both. Standard readout accessories include (1) in-line numerical, (2) 26-wire decimal digital and 3-wire "staircase." Visual and electrical readout may also be specified . . . (*From new 6-page Bulletin 6010 James Cunningham, Son & Co., Rochester 8, N. Y.*)

CIRCLE 125 ON READER-SERVICE CARD

Electrically Suspended Rotor Gyro is Miniaturized

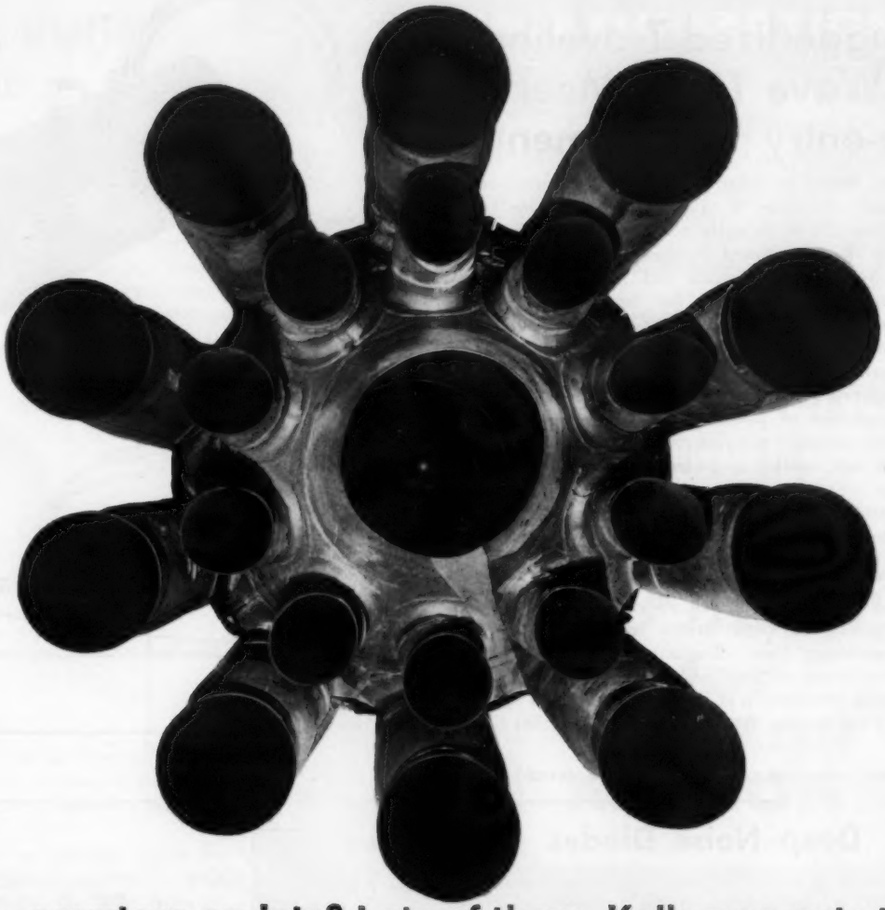
Miniaturization of the electrically suspended rotor gyroscope (ESG) has been announced by Minneapolis-Honeywell, Minneapolis, Minn. The hollow beryllium rotor, approximately the size and weight of a ping-pong ball in the new version, is suspended in a vacuum within an enclosure by means of an electric field. With this suspension the drag on the sphere is so low that the gyro can be used for years without any further spin power being applied. Angular position of the rotor is picked off by means to avoid loading the rotor.

SHINY BALL being checked for sphericity to better than five-millionths of an inch is the rotor of the new miniature electrically-suspended gyro for space vehicle guidance.

Originally developed for the Polaris navigational system, in which size and weight was not as critical, the miniaturization of the ESG now makes it as small as conventional space gyro systems. The rotor, ceramic envelope for the rotor, optics, electronics and vacuum pump are all contained in a cylinder 3½" diameter x 4¾" long and weighing less than four pounds. Four watts of power are more than enough to operate it.

Because the new system requires no gimbals, moving parts are reduced to only the rotor, which means a major increase in reliability. Also, since little power is required to suspend the rotor in space applications where very low "G" levels obtain, power requirements for space navigational gyros will be small. The suspension system could also be instrumented to sense acceleration, according to Honeywell engineers, thus eliminating the need for separate accelerometers. A space inertial platform consisting of only two ESG gyros thus becomes practical.

CIRCLE 126 ON READER-SERVICE CARD



what!—counters on jets? Lots of them. Kollsman puts them there. And Veeder-Root supplies Kollsman, providing jet pilots with direct read-out—immediate indication of the vital data necessary for controlling aircraft travelling at jet speeds. Can Veeder-Root help your performance? Better find out. Write to Instrument Section, Veeder-Root Incorporated, Hartford 2, Connecticut. **count on . . . Veeder-Root**

KOLLSMAN INSTRUMENT CORP.

Modern thrustmeter—one of many special instruments which uses Veeder-Root counting ingenuity—shows pilots the power conditions necessary for safe take-off.

CIRCLE 36 ON READER-SERVICE CARD

Ruggedized Traveling Wave Tubes Meet Re-entry Environments

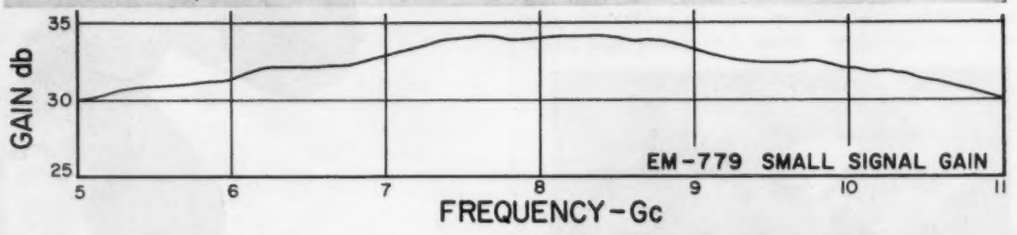
A new family of fifteen traveling wave tubes covering frequencies from 2 to 12 gigacycles with power levels from 0.5 to 5 watts and providing gains from 30 to 60 db are offered by Eimac for a wide range of high-performance aircraft and missile applications.

Typical small signal gain for the EM-779 traveling wave tube rated at 1 watt minimum over the 5 to 11 Gc band is shown in Fig. 1. The use of temperature compensated permanent magnets allows the new tubes to be operated over a wide temperature range without degradation of performance. Under environmental conditions normally encountered in military equipments, the heat sink cooling provided by the mount will be adequate.

A patented method of supporting the helix by ceramic rods held in molybdenum clips results in superior vibration and shock characteristics and permits the tube to be directly mounted, without shock supports, on the missile frame. Wide bandwidth results from attaching the helix directly to the input and output transmission lines, eliminating the usual narrow-band transformer sections. Input and output impedances of the tubes are uniform at 50 ohms nominal. *(From new 62-page TWT catalog, Eitel-McCullough, Inc., San Carlos, Calif.)*

FOR THIS LITERATURE CIRCLE 113 ON READER-SERVICE CARD

RUGGEDIZED Type 779 Traveling Wave Tube. Gain in excess of 30 db is shown over the 5 to 11 mc range.



Deep Noise Diodes

Solitron SD Sounvisters® are hermetically sealed, double-diffused silicon junction diodes operating under parameters such that they are effective, easily energized sources of random noise-producing voltages. When a suitable dc voltage is applied in a reverse mode across a feed-resistor in series with a Sounvister, a reverse current comprised of innumerable discrete, random, dc pulsations differing widely in size and duration results (Fig. 1). The dc pulsations are converted to ac voltage excursions via a traditional capacitor-grid leak coupling system. The converted ac voltages, commonly known as noise voltages, are impressed across the high impedance input of a linear voltage amplifier with adequate gain to raise them to a desired operating level. The noise voltages obtained from Sounvisters encompass a spectrum extending from 1 cps up to 100 mc (Fig. 2).

The performance of each SD unit in a particular circuit configuration at an ambient temperature between 25° and 30°C is carefully studied in the Sounvister Laboratory. The most effective operating parameters and the distribution of noise voltage amplitudes within a 20 cps to 25 mc spectrum is determined. The results of this study are attached to each unit in the form of a classification code number. This number plus two simple application formulae enable a designer to energize a particular Sounvister under a variety of operating parameters with assurance that the unit's performance in each case will duplicate that measured in the laboratory.

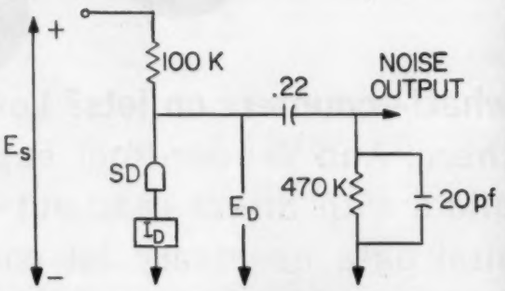


FIG. 1. CLASSIFYING CIRCUIT for SD-1 Sounvistor Diodes.

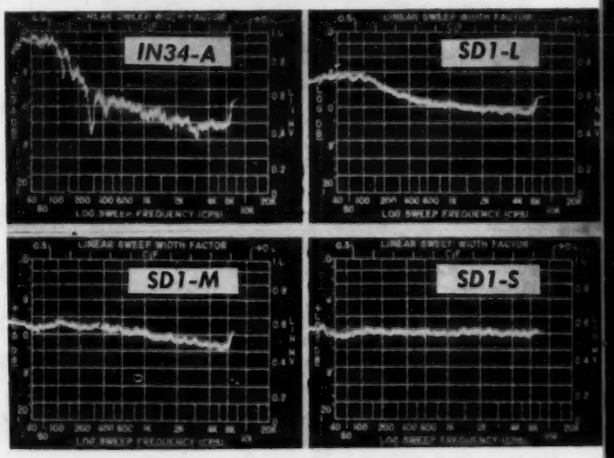
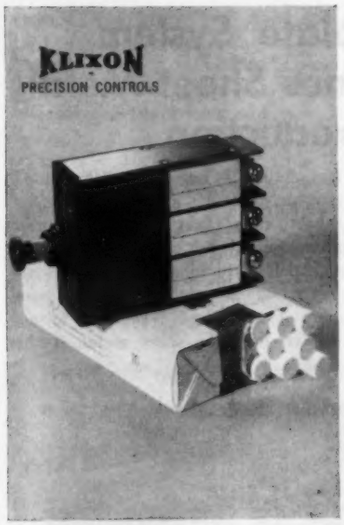


FIG. 2. NOISE VOLTAGE Spectra from three SD-1 Sounvistor Types are compared with that from typical IN34-A diode, long used as a white noise source.

The reverse current in SD1's can be raised safely to several hundred microamperes without exceeding the 250 milliwatt dissipation capability of the junction. Energizing voltages across the junction are low enough that puncture is not a problem. Typically, the lower reverse currents result in the smoothest noise voltages. The noise voltage output is held to ± 2 db referred to the output specified for each unit.

The spectral distribution of noise voltage amplitudes of the L, S, and M types, generally holds constant over fairly wide reverse current levels. It may change in an unpredictable manner at very high reverse currents. The W type units usually display other patterns until they reach maximum noise voltage output. From this point further current increases simply reduce the output while the spectral pattern remains constant . . . *(From new 16-page "White Noise Diode Manual," Solitron Devices, Inc., 500 Livingston St., Norwood, N. J.)*

FOR THIS LITERATURE CIRCLE 114 ON READER-SERVICE CARD



GUARD LOW-AMP ELECTRONIC CIRCUITS!

New single-button 3-phase thermal circuit breaker combines small size and fast response!

This compact package integrates three miniature push-pull circuit breakers to bring unprecedented 3-phase protection to electronic components and cable in the ½ to 10 amp range. An overload on any one phase trips all three breakers — and releases the single indicating button. When the button stays in, everything's "A-ok".

Tripping response is comparable with the speed of a slow-blow fuse . . . 2 to 20 sec at 200% rating. Since the KLIXON 7276 breaker is thermally responsive, it avoids nuisance trips on harmless current transients.

For complete performance and test data on the new KLIXON 7276 3-phase circuit breaker, write for Bulletin CIRB-27.

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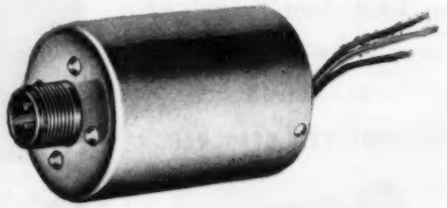
CIRCLE 37 ON READER-SERVICE CARD

RFI Filter Installation Criteria

The satisfactory operation of all filters employing the case as part of the circuit depends upon adequate bonding of the filter to the same potential as one side of the RF noise source being filtered. A radio noise filter uses the case as common ground for the internal capacitors; therefore, if the case is not bonded to the source being filtered, resistance, capacitance, inductance, or combinations thereof may be added in series with the capacitor elements of the filter and greatly effect the shunting and attenuation properties of the circuit. In many installations disregard of good bonding practice reduces the insertion loss to unacceptable levels.



CYLINDRICAL Filters afford maximum isolation between input and output leads.

The location of a filter is fully as important as the design of the filter circuit. The filter must be located as near the interference source as possible. The filter must be well bonded at radio frequencies to the case of the interference source, as noted above. Without proper selection of location, the interference voltage will couple into all nearby leads or conductors, resulting in the need for multicircuit filters rather than the single filter at the source. Proper filter location can also make the problems of grounding, lead dress, lead shielding, etc., less critical.

In order to maintain the insertion loss properties of the filter, it is important to use the correct lead dress. Input and output wires must be separated by the greatest possible distance. Leads to and from the filter should never be dressed into the same harness. In cases of high level interference voltages, shielded or double shielded wire must be used between the interference source and the filter. In general, a properly designed and installed RF filter does not require shielded leads both to and from the filter unless there is coupling to the "clean" lead. Cylindrical filters afford maximum isolation between the input and output leads. Upon request, Genistron can supply most of their rectangular filters with one terminal located on the bottom of the case to afford additional lead isolation . . . (*From 44page Radio Interference Filter Catalog F*101, *Genistron, Inc.*, 16320 *W. Arizona Circle, Los Angeles* 45, *Calif.*)

FOR THIS LITERATURE CIRCLE 115 ON READER-SERVICE CARD

CIRCLE 38 ON READER-SERVICE CARD →

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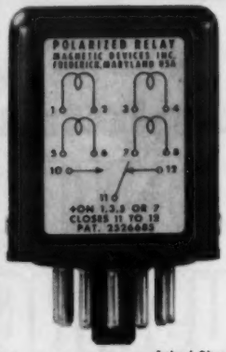

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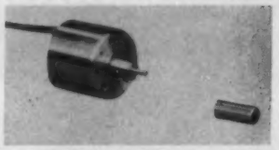
CIRCLE 39 ON READER-SERVICE CARD

DIFFERENTIAL TRANSFORMER



New Bulova Altimeter using two Acotran Linear Variable differential transformers is reported to be ten times more accurate than conventional altimeters because differential transformers convert motion to voltage without exacting mechanical work. Electrical signals can be algebraically summed with other differential transformers.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

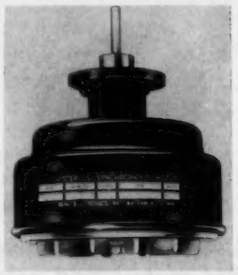
CIRCLE 127 ON READER-SERVICE CARD

LINEAR POT PICK-OFF

New Model 10111 linear motion pickoff for conversion of linear motion into linear or non-linear voltage provides linearity better than 0.05%/inch travel in resistances from 500 to 100,000 ohms/inch. Non-metallic film element is non-inductive and ganged units with matched characteristics can be supplied.—*Computer Instruments Corp., 92 Madison Ave., Hempstead, L.I., N. Y.*

CIRCLE 128 ON READER-SERVICE CARD

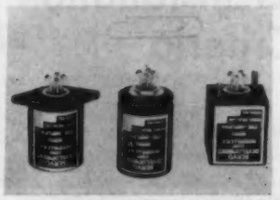
THREE-SPEED SYNC MOTOR



New three-speed hysteresis motor with output speeds of 300, 600 or 1200 rpm operates from 115v 60 cps; is insensitive to voltage changes of 40 volts in either direction. Designed for precision tape drives it is also applicable as drive for facsimile systems. Runout of stainless steel, hard chrome plated capstan is guaranteed less than .00015" max.—*Beau Electronics, Inc., Waterbury, Conn.*

CIRCLE 129 ON READER-SERVICE CARD

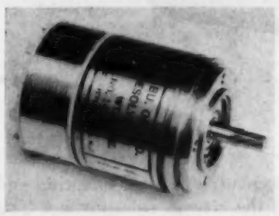
SERVO PREAMPLIFIER



New Model 51-100 transistorized servo pre-amplifier using silicon transistors for 125°C operation provides a normal gain of 1200 at 3000-ohms input impedance with output of 2 v rms across a 10,000 ohm load. Used with Model 50-100 amplifier it delivers up to 3.5 watts at 40 volts to size 11 servo motor.—*Servo Development Corp., 2 Willis Court, Hicksville, L.I., N. Y.*

CIRCLE 130 ON READER-SERVICE CARD

COMPENSATED RESOLVER



New Model T980-003 Size 15 winding- compensated resolver for applications in computer, data transmission and other precise analog systems features 0.1% max function error. Is equivalent to BuOrd MK4 Mod 1 unit. Data on request.—*Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N. J.*

CIRCLE 131 ON READER-SERVICE CARD

MINIATURE MOTOR

New compact, high-performance hysteresis, synchronous and induction miniature motors with extremely low-watt input (1.5 watt min) are up to 25% efficient in size 11 bifilar winding models. Synchronous motors—furnished in counter-rotating matched pairs for inertial guidance systems, satellite applications and other high-precision uses—are said to start and achieve synchronism together.—*Martronics, Inc., 82 Sanford St., Hamden 14, Conn.*

CIRCLE 132 ON READER-SERVICE CARD

Template System Streamlines Sheet Metal Production

Sheet metal fabrication by a new "Templamation" system eliminates many costly steps conventionally required in punched sheet metal fabrication. The new technique makes templates in metal up to 36" x 42", rapidly inspects the finished template to assure accuracy to tolerance of ± 0.002" and applies the template in the Wiedemann Turret Press (Fig. 1) to accurately locate and pierce holes in sheet metal at the rate of 15 to 40 per minute.

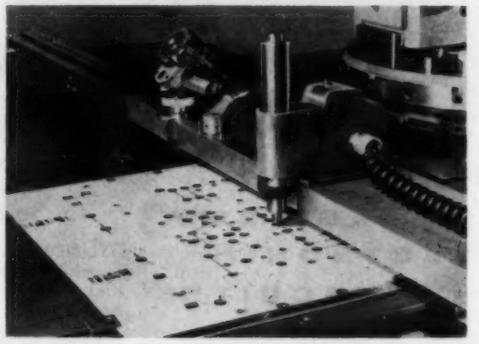


FIG. 1. WORK-LOCATING Template as used on Type RA41P Wiedemann turret punch press.

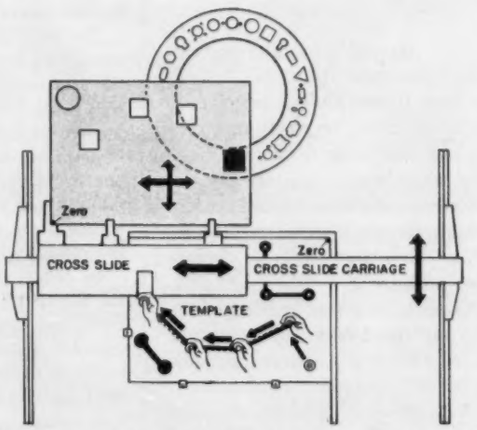


FIG. 2. COLORED HOLES in template identify tool in turret head to be used. Line shows progress of work.

The new method eliminates layout, setup, special die sets and multiple handling, while permitting unlimited engineering changes. It is particularly applicable in low quantity producton because small numbers of finished parts can be economically produced. Only one punch and die of each size is required because each size and shape of die is immediately available by rotating the punch press turret.

In use, a template which has been cut on the Weide-

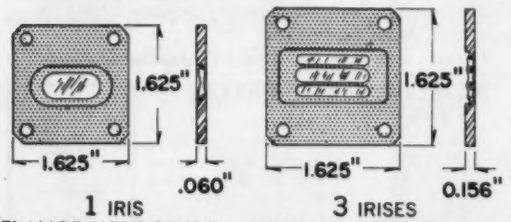
mann Coordinator® and rapidly checked on an independent inspection table is fastened to the punch press table. Here it is located in direct relationship to the work on the moveable cross slide. For each opening, the operator simply moves the stylus to engage a ¼" dia. hole in the template (Fig. 2). This positions the work under the punch and trips the press. Color coding of template holes corresponds to the same color punch and die. To change tools, simply rotate the turret, which accommodates all tools normally used. The method is unmatched for high-speed piercing of repetitive work with intricate hole patterns . . . (*From 4-page bulletin 350-T, "Wiedemann Templamation," Wiedemann Machine Co., Gulph Rd., King of Prussia, Pa.*)

FOR THIS LITERATURE CIRCLE 133 ON READER-SERVICE CARD

Waveguide Pressure Windows

Pressure windows provide a vacuum-tight seal within waveguide systems, while passing microwave energy freely. The maintained pressure assures maximum performance, and the tight seal prevents entry of moisture, dirt and dust. MDL pressure windows seal antenna systems, resonant cavities, gas discharge and vacuum tubes, and ferrite components. Bandwidth is influenced by the size, shape, and number of slots in the window.

All MDL pressure windows are silver plated to reduce



FLANGE WINDOWS For WR90 Waveguide for center frequencies of 9.8 Gc in 1- and 3-iris styles are shown. Peak power and max VSWR for single iris style are 300 kw and 1.25; for triple-iris are 200 kw and 1.20, respectively.

rf loss. The flange windows mount between two choke flanges fitted with rubber "O" ring seals. The pressure seal in solderable windows is maintained by the solder itself.

MDL Pressure windows are produced by fusing glass to preoxidized metal of the same expansion coefficient. The union of the metal oxide with the glass creates a strong, vacuum-tight bond that withstands any differential pressure found in waveguide applications. Specially tempered, prestressed glass is used for added strength.

A safety factor is included in the power handling specifications of all MDL pressure windows. All window surfaces are design-tested at atmospheric pressure with a one micro-second pulse at 100 pps repetition rate.

Pressure windows for special applications can be developed by modifying stock windows, or MDL engineers will design a completely new window to your requirements . . . (*From 4-page catalog WD-61, Microwave Development Laboratories, Inc., 15 Strathmore Rd., Natick Industrial Centre, Natick, Mass.*)

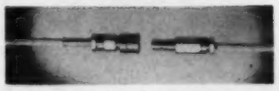
FOR THIS LITERATURE CIRCLE 134 ON READER-SERVICE CARD

CONTACT POINT FEED-THRU

New Type FT-SM-706 feedthru provides contact point and terminal connection in a single Press-Fit teflon insulated unit. Contact point is cone-tipped with sharp apex for minimum contact resistance on low-current control circuits. Small size, .125" dia x .218" length, fits high-density designs. —*Sealectro Corporation, 139 Hoyt St., Mamaroneck, N. Y.*

CIRCLE 135 ON READER-SERVICE CARD

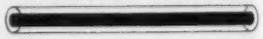
DAMAGE-FREE SNAP CONNECTOR



New "ConheX" Snap-On connector features brass captivating member over the spring which limits bending off the axial dimension when connector is disconnected. This prevents spring damage, greatly increases life. —*Sealectro Corporation, 610 Fayette Ave., Mamaroneck, N. Y.*

CIRCLE 136 ON READER-SERVICE CARD

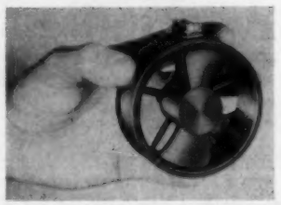
RUBY LASER RODS



New ruby rod with sapphire overlay offers increased capture cross section for better efficiency, also increased conduction area for better cooling and operation at lower threshold levels.—*Valpey Crystal Corp,. 1244 Highland St., Holliston, Mass.*

CIRCLE 137 ON READER-SERVICE CARD

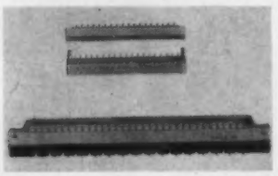
TINY FAN



Space and weight-saving Propimax 2 fan, just over 3" diameter, 1½" deep and weighing 6.5 oz moves 17.5 cfm, free delivery, while drawing .05 amp at 115v 60 cps. Reverses direction by turning end-for-end, mounts by servo ring.—*Rotron Mfg. Co., Inc., Woodstock, N. Y.*

CIRCLE 138 ON READER-SERVICE CARD

MICRO P-C CONNECTOR



New Series MPC-37 two-piece contact connector of glass reinforced diallyl phthalate per MIL-M-19833 is only 1/6 the size of previously available connectors, gives maximum density with high reliability under maximum mechanical and environmental stresses.—*U. S. Components, Inc., 1320 Zerega Ave., New York 62, N. Y.*

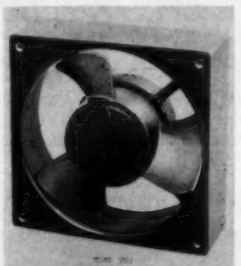
CIRCLE 139 ON READER-SERVICE CARD

QUICK DIS-CONNECTOR

New Model P/N 200 73004 quick connect/disconnect electrical coupler designed to separate under only 0.70 pounds force has contacts rated at 45 amps and takes wires up to #12 AWG. Originally developed for missile separation, connector has many uses in industry and test laboratories. —*Kellett Aircraft Corp., Willow Grove, Pa.*

CIRCLE 140 ON READER-SERVICE CARD

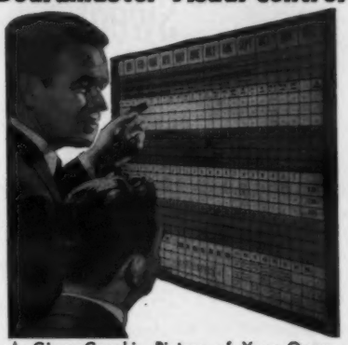
BRUSHLESS DC MOTOR/FAN



New 100 cfm Model 3201 Brushless DC fan eliminates electrical noise and arcing at high altitudes with higher reliability and long life. Speed proportional to voltage from 20v to 40v dc. Other brushless models give constant speed over wide variation of dc voltage.—*Astrodynamics, Inc., Northwest Industrial Park, Burlington, Mass.*

CIRCLE 141 ON READER-SERVICE CARD

You Get Things Done With Boardmaster Visual Control



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1-7/16" thin, of light-weight, modern construction; when supplied with a straight edge or drafting machine, as shown, unit becomes a self-contained drafter.

Use on drafting board, bench or desk. Diffusers on fluorescent lamps give strong yet glare-free lighting of work. Permits tracing of light lines or curves, or comparison of two or more superimposed layouts or details to spotlight interferences and errors. Other uses:

- Inspection of thin boards and materials for cracks or defects
- Viewing of X-rays or negatives
- Display of signs, educational matter, transparencies (built-in easel available)
- Art Work: tracing on Bristol board, Multilith or Mimeo mats, or stripping-in and opaquing negatives

Light weight and thin design encourage use on regular drafting board, permit unit to be stored with reference books, ready for next user. It pays for itself in a short time.

CONSTRUCTION: Stainless steel frame; shatterproof acrylic diffuser top (with protective glass cover when used with razor blades); built-in switch; rubber feet; available in 5 standard sizes up to 36" x 48", starting at $32.50. Send for FREE literature — no salesman will call.

PORTA-TRACE INC.
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CIRCLE 41 ON READER-SERVICE CARD

Swept-Frequency SWR Measurements

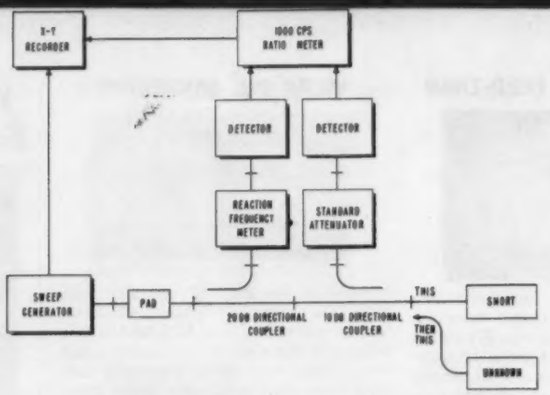

FIG. 1. SWEPT-FREQUENCY method, SWR measurement.

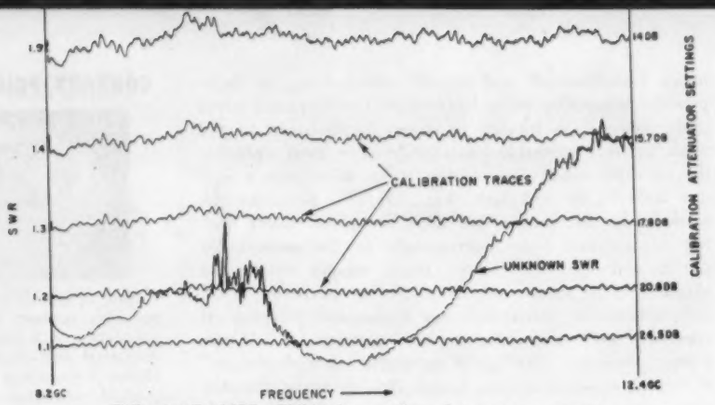

FIG. 2. CALIBRATION lines allow for system errors.

Measurement of standing wave ratio using early reflectometers has been subject to a variety of calibration errors, among which was the change due to the use of the reverse detector in a low power region after its initial calibration in a 100% reflection region.

The improved reflectometer system shown in Fig. 1 materially reduces such calibration errors. Continuous calibration over the entire frequency range is afforded by a rotary vane attenuator in the secondary arm of the reverse coupler.

The attenuator, in effect, pre-inserts the return losses anticipated for actual tests. With the attenuator in the system, a frequency sweep of the reference short yields calibration traces that include most system errors. A series of such traces can then be compared with the performance trace of the instrument being tested on a go/no-go basis.

The step-by-step procedure for SWR measurement is as follows:

1) Connect the 100% calibrating short to the reference coupler (Fig. 1).

2) Set the expected value of return loss into the standard rotary vane attenuator. For instance, if the expected SWR is 1.2 the standard attenuator should be set to 20.8 db (Return loss $= 20 \log \rho = 20 \log$ (SWR-1/SWR $+ 1$).

3) Set the ratiometer range and the X-Y recorder sensitivity to keep the pen on scale.

4) Sweep the frequency generator over the required range to obtain a calibration plot of Frequency vs SWR.

5) Reset the attenuator to simulator other SWR values and plot additional calibration lines (Fig. 2). Only two calibration lines give enough information for go/no-go tests.

6) Replace calibrating short with unknown load.

7) Return the standard attenuator to zero db and trigger the final measurement sweep. The trace labelled "Unknown SWR" in Fig. 2 shows instrument SWR characteristic between 8.2 and 12.4 Gc.

8) Where repeated tests of identical instruments are to be performed, the calibrating traces can be inscribed on transparent paper for comparison with each instrument trace . . . (*From new 32-page catalog of Microwave Instrumentation, Hewlett-Packard Company,* 1501 *Page Mill Road, Palo Alto, Calif.*)

FOR THIS LITERATURE CIRCLE 142 ON READER-SERVICE CARD

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CIRCLE 42 ON READER-SERVICE CARD

DELAY/INERTIA SWITCH

New miniature gas-damped time delay inertia switch for military applications where acceleration and time integration is required can be set to function at ranges as high as 50 G-seconds. Variation in time delay between −65°F and 250°F is only 25%.—*Inertia Switch, Inc.,* 311 *W.* 43 *St., New York, N. Y.*

CIRCLE 143 ON READER-SERVICE CARD

SPEED SWITCH DIODE

New gallium arsenide "Nanoswitch" ultra-fast switching diode, is available in three different types for logic circuits with max recovery times from 0.5 to 1.0 nanoseconds. Max inverse current is 1.0 μamp at 25°C and 10 μa at 300°C. Peak pulse current is 300 ma and max forward voltage is 0.6 v.—*Diotron, Inc.,* 3650 *Richmond St., Philadelphia* 34, *Pa.*

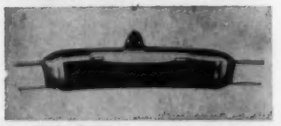
CIRCLE 144 ON READER-SERVICE CARD

SMITH CHART PLOTTER

New plexiglass Mega-Plotter, using standard 8½" x 11" Smith Charts, speeds neater, more accurate answers to transmission line or polar antenna radiation problems.—*Kay Electric Co.* 14 *Maple Ave., Pine Brook, N. J.*

CIRCLE 145 ON READER-SERVICE CARD

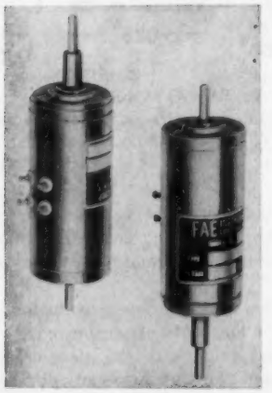
GRAVITY SENSING POT



New EP 100 Series Gravity Sensing Electrolytic Potentiometers for gyroscope correcting mechanisms and other controls utilizing a gravity reference or tilt indication consist of curved glass tube with air bubble in electrolytic solution. Motion of air bubble changes impedance by changing immersion of top electrodes.—*Hamlin, Inc., Lake Mills, Wisc.*

CIRCLE 146 ON READER-SERVICE CARD

MAGNETIC CLUTCH-BRAKES



New BuOrd Size 11 series direct action miniature magnetic clutch-brakes permit independent clutch or brake functions within a single unit. Friction-coupled Type F-75 uses hard, flat contact faces for minimum angular engagement error and long slip life, while crown-tooth coupled F-85 gives highest torque.—*FAE Instrument Corp.,* 16 *Norden Lane, Huntington Station, N. Y.*

CIRCLE 147 ON READER-SERVICE CARD

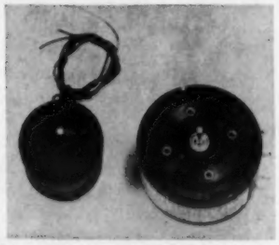
For more information on products reported or advertised in this issue, use postage free card bound in this issue -- or write number and date of issue on card and send c/o our Reader Service Department.

SIZE 9 AC POTENTIOMETER

New Model 5B01 size 9 Vernistat with terminal conformity of ±.05% provides output impedance of 160 ohms max with a minimum input impedance of 60,000 ohms. Operates at 28 v ac and is particularly suitable for use as a follow-up element in servo systems, as a computer element and a data transmitter.—*Vernistat Division, Perkin-Elmer Corporation, Norwalk, Conn.*

CIRCLE 148 ON READER-SERVICE CARD

LIMITED ROTATION MOTORS



New Series 90 Limited Rotation motors are high efficiency current-to-torque transducers without wiping contacts. Outputs range from 0.1 oz-in for size 15 motor to 2.0 oz-in for size 23 motor from ac, dc or pulse train currents.—*Power-Tronic Systems, Inc., Pine Court, New Rochelle, N. Y.*

CIRCLE 149 ON READER-SERVICE CARD

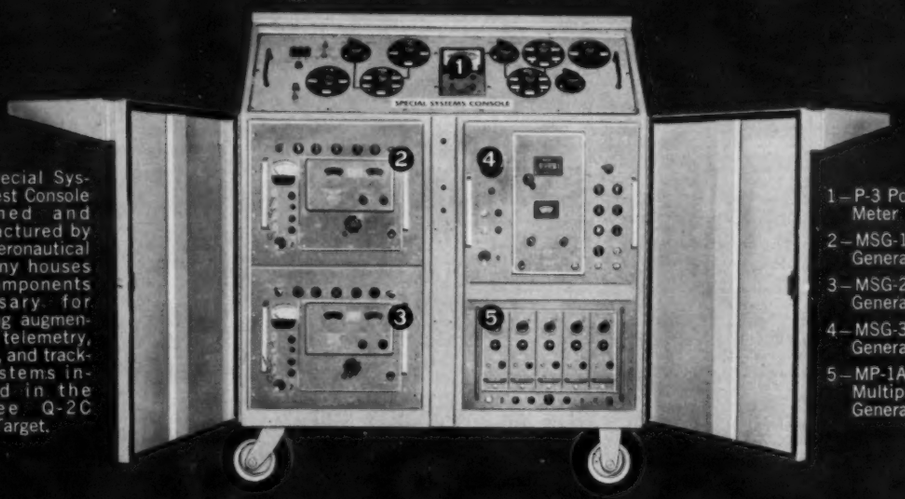
A/D TRANSLATOR/DISPLAY

New TADD-4-BCD transistorized translator and decimal display unit gives an immediate digital readout of the encoder information at any instant. Binary coded decimal is translated into the decimal equivalent. Because TADD is completely transistorized it is faster than relay type readouts now available.—*Norden Div. of United Aircraft Corp., Helen St., Norwalk, Conn.*

CIRCLE 150 ON READER-SERVICE CARD

Ryan Aeronautical Company's Firebee Q-2C Aerial Target

the Polarad microwave catalog saved hundreds of man-hours in this Ryan Test Console



The Special Systems Test Console designed and manufactured by Ryan Aeronautical Company houses the components necessary for checking augmentation, telemetry, scoring, and tracking systems installed in the Firebee Q-2C Aerial Target.

1—P-3 Power Meter
2—MSG-1 Signal Generator
3—MSG-2A Signal Generator
4—MSG-34 Signal Generator
5—MP-1A Multipulse Generator

Astute project management by Ryan saved substantial design and development man-hours in the building of the Air Force Special Systems Test Console for checking Q-2C Aerial Targets.

Ryan's alert design engineers combined standard Polarad Microwave Test Equipment, as listed in the Polarad Catalog, with control circuitry, resulting in quick conversion of ideas to contract completion. Prime and sub-contractors throughout the country have discovered that Polarad's Catalog Microwave Test Equipment is built to the rugged standards that enable their use in the military systems—to stand up under the most adverse field conditions.

Before you commit your Design Equipment Department to costly development work on microwave equipment, check the Polarad Catalog. It contains nearly every basic microwave test instrument available today, including signal generators from 500 to 50,000 mc, receivers from 400 to 84,200 mc, and spectrum analyzers from 10 to 100,000 mc. Your copy sent on request. Polarad's Field Service Department will be happy to help you solve your problems with standard or *modified* Polarad equipment.

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CIRCLE 43 ON READER-SERVICE CARD

CALIBRATED FIELD INTENSITY RECEIVER Model CFI is highly transistorized for field use in a wide range of interference and field strength measurement, operating from either 12 vdc or 50-60 cps, 115 vac sources. Block diagram shown below indicates its versatility.

Calibrated Field Receiver is Multiuse Instrument

The Polarad Model CFI Transistorized Microwave Calibrated Field Intensity Receiver consists of four interchangeable r-f tuning units, a basic unit, an impulse calibrator, five antennas and a tripod. In use, the instrument with one tuning unit installed measures 19" x 15¾" x 21½" and operates from 115V ac 50-60 cps or 12V dc 20 ampere power.

Four overlapping r-f tuning units cover the frequency range from 1 to 10 Gc.

The Transistorized Microwave Calibrated Field Intensity Receiver Model CFI combines a calibrated receiver, an internal calibrated impulse signal generator and a calibrated antenna system. It indicates the absolute power level of a radiated or conducted input signal. The signal level indication is in microvolts, db above 1 microvolt, db above 1 microvolt per megacycle, 70 db for relative measurements, and a 20 db linear scale.

Signals to be measured may be applied to the impulse calibrator unit. In the USE position of the front panel control, the incoming signal may be attenuated (up to 60 db), then coupled to the appropriate plug-in r-f tuning unit. This signal is then sent through a tunable two-cavity preselector to a first crystal mixer.

The klystron local oscillator mixes with the incoming signal resulting in a first i-f frequency of 260 mc. Automatic frequency control (AFC) may be applied to the repeller of the klystron oscillator to lock the receiver on the signal in spite of signal frequency drift.

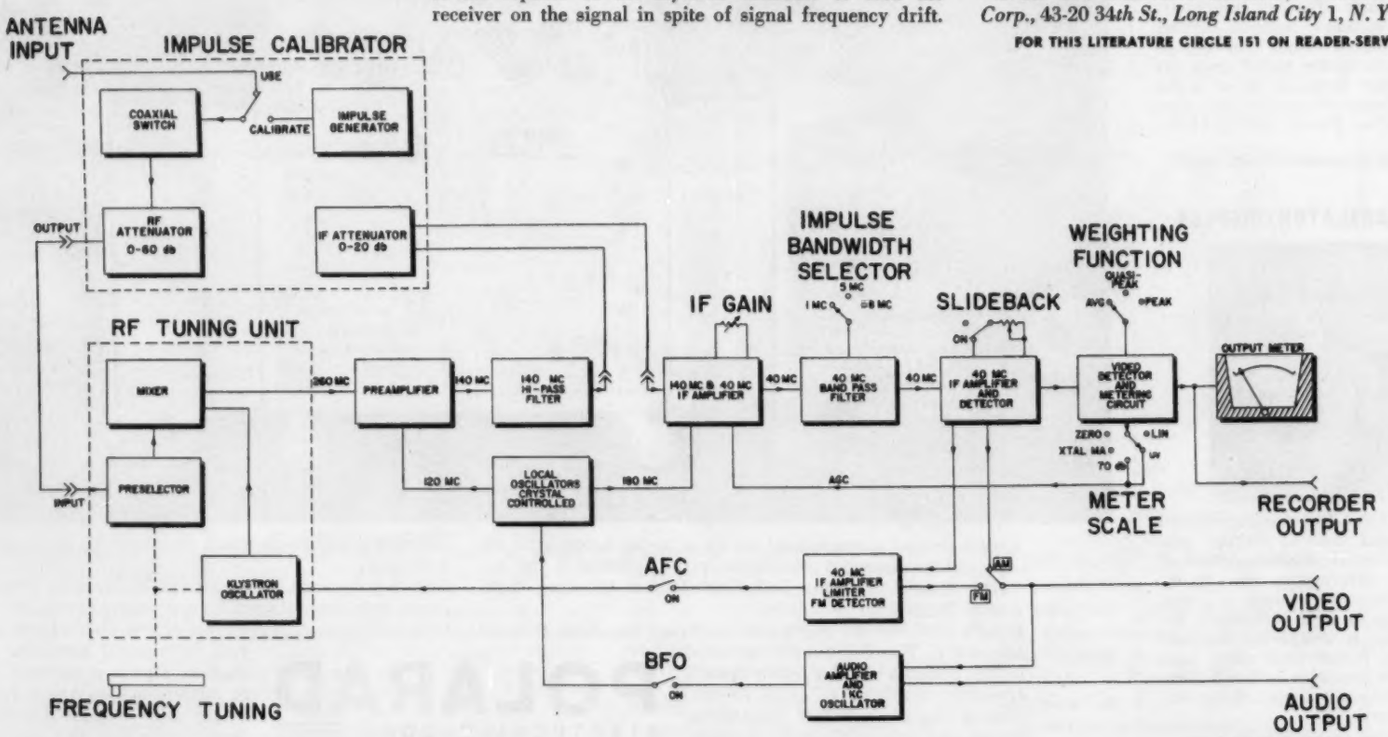
The front-panel tuning control simultaneously adjusts the preselector band pass frequency, the klystron cavity resonant frequency, and the klystron repeller voltages.

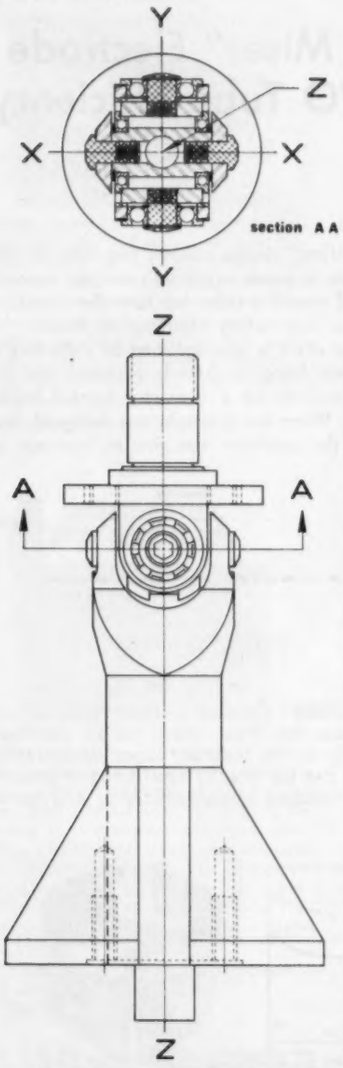
The 260 mc i-f output of the first crystal mixer is amplified in a preamplifier and converted to 140 mc by subsequent mixing with a 120 mc crystal-controlled local oscillator signal.

The 140 mc second i-f output of the preamplifier is filtered, and attenuated (if desired) and amplified in a main i-f amplifier stage. The amplified signal is heterodyned with a 180 mc output of the crystal-controlled local oscillator, yielding a 40 mc third i-f signal. This i-f signal is coupled to a 40 mc bandpass filter where a particular bandwidth (either 1 mc, 5 mc, or 8 mc) can be selected. This final i-f signal is then amplified and detected in a final i-f amplifier and detector. The detected signal is applied to a metering circuit, a limiter and FM detector, and an audio amplifier.

In the Calibrate position of the Use-Calibrate control, the incoming r-f signal is disconnected enabling the output of the impulse calibrator to calibrate the instrument. In this manner the equipment determines the absolute r-f power measurement of signals by first, calibrating its internal circuitry with a standard reference (impulse calibrator) and secondly, indicating its response to an external signal . . . (*From* 6-page folder *"Model CFI Calibrated Receiver," Polarad Electronics Corp.*, 43-20 34*th St., Long Island City* 1, *N. Y.*)

FOR THIS LITERATURE CIRCLE 151 ON READER-SERVICE CARD





"Inside-Out" Gyro Gimbal

The gyro gimbal assembly here illustrated is used in the nose cone of a air-to-air missile. The gyro rotor (not shown) rotates about the Z axis and envelops the gimbal assembly like an umbrella. This mounting design reduces the space required for the gyro assembly and, in air-to-air missiles, this is very important.

The assembly shown has two degrees of freedom and permits 45° motion of the spin axis about either gimbal axis. This provides a relatively wide scope for the heat-sensing missile guidance system of which this assembly is a part. The flanged gimbal bearings on the X and Y axes are lightly preloaded at assembly to eliminate the axial and radial play of the assembly.

To obtain the gyro operating accuracy required of this application, it is imperative that the X, Y, and Z axes intersect at a single point. This is particularly important in this "inside-out" gimbal arrangement because the center distance between bearings is relatively very small and a small amount of misalignment between gimbal bearings results in a relatively large angular displacement of the gimbal axis.

The spin axis bearings for this gyro are not shown in the drawing, but are mounted on the Z axis stub shaft at final assembly. These bearings are supplied by MPB to the gyro rotor manufacturer for sub-assembly into rotor wheels.

The illustration is twice actual size. Components of this assembly are made of heat treated stainless steel. The size and extreme accuracy of the parts, the accuracy and skill required in assembly, and the reliability demanded of the final assembly is typical of Precision Products made by MPB . . . (*From 64-page catalog 6, Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.*)

FOR THIS LITERATURE CIRCLE 152 ON READER-SERVICE CARD

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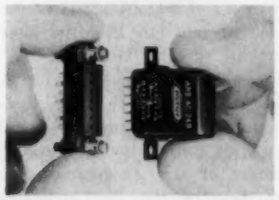
ACCELEROMETER SWITCH

New AS31 Series Accelerometer Switch covering ranges of ±1G up to ±50 G (or higher on order) weigh about 4 oz., and measure 1.7" long x 1.03" dia. These offer rapid response time to steady-state accelerations but are insensitive to low frequency vibration, meet MIL-S-8484, Grade A.—*Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.*

CIRCLE 153 ON READER-SERVICE CARD

RELAY SOCKET



New socket assembly No. 2999, to fit Branson Type AR microminiature four-pole relay is designed for operation in a temperature range of −65° to 126°C and with a dielectric strength of 1500v rms between terminals. Fourteen numbered socket holes have standard 0.1" spacing.—*Branson Corporation, Box 234, Whippany, N. Y.*

CIRCLE 154 ON READER-SERVICE CARD

Ordinary AC VTVM's measure voltage . . . **only.** Then, too, they are "earth-bound"—practically **tied** to their case and power line. Not this one!

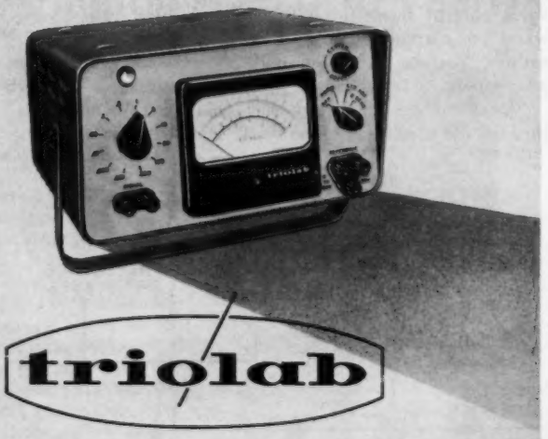
The Model 131-1 tells you almost everything a reasonable man could want to know about an AC signal: **voltage** (at or *above* ground), **phase, phase-shift, in-phase and quadrature components.** It will measure amplifier **gain/phase** characteristic and **angular error** in servo devices. It's also a feedback-stabilized, linear amplifier, for simultaneous CRO waveform observation.

How natural for **trio/lab,** 8-year pioneers in "build-ins" (the **most** VTVM in the **least** space at **minimum** cost) to put this accurate, versatile, reliable workhorse on your lab bench for only **$345!**

For $100 less, you can enjoy the "floating" sensation without the phase-discriminating feature — Model 109-2. Both are in stock.

Triple your measuring capabilities with this unique new VTVM!

Normal and Phase-Discriminating modes . . . both "floating" from ground.



TRIO LABORATORIES, INC., PLAINVIEW, L. I., NEW YORK
OVERBROOK 1-0400, AREA CODE 516, TWX HKVL 1168

CIRCLE 44 ON READER-SERVICE CARD

Ruggedized AC TRVM is Phase Sensitive

FIG. 1. TRANSISTORIZED AC VOLTMETER Model 302-1 is ruggedized single-range phase-sensitive instrument for inspection and monitoring applications in military systems.

Phase-sensitive detection of ac signal voltages can now be accomplished by a miniature, panel-mounting Model 302-1 all-transistor voltmeter designed for monitoring and inspection of military systems. Although the meter (Fig. 1) uses no more panel room than required for its 3½" indicating meter and extends to a length of only 6½", it is complete with its own power supply system and internal reference isolation transformer. Signal circuits are isolated from both power and case potentials to facilitate accurate voltage measurements. All terminals are mounted on the rear board, as is the calibration potentiometer, the only electrical adjustment ever required for periodic calibration.

Phase Sensitive Voltage Measurement

In most ac VTVM's the input signal is fed through a calibrated attenuator and an ac amplifier. A rectifier bridge (demodulator) converts the amplified ac signal into dc which is read on a simple current meter. The phase-sensitive TRVM is much the same except that rectification occurs in a half-wave ring demodulator made to act as a gating circuit (Fig. 2). In following this simplified schematic each diode should be regarded as a current-controlled switch having very low resistance when current flows through, and very high resistance when no current is flowing. Within the usual diode ratings, current will flow only when voltage of the proper polarity is applied.

Signal voltage alone of any polarity cannot flow through the meter since one diode in either bridge arm is open to it. If the reference voltage makes point A more positive than point B, the polarity orientations still prevent current flow through the bridge and all the signal current flows through R1. When point B is more positive than point A, however, the reference current will flow through all four diodes, enabling the signal current to pass through the four diodes and the meter.

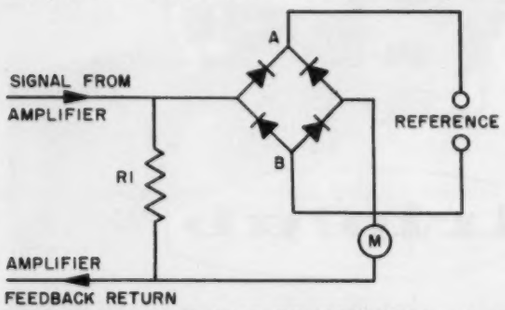


FIG. 2. HALF-WAVE RING DEMODULATOR acts as phase sensitive gating circuit. Signal current flows in meter circuit only when B is positive with respect to A.

The average value of this meter current is directly proportional to the V cos θ, where V is the magnitude of the signal voltage and θ is the phase angle between the signal and reference voltages. Analysis of average current flow shows that even harmonics are completely cancelled, resulting in zero meter current. Odd harmonics in the worst case, when in phase with the reference, are attenuated in proportion to their frequency ratio: third harmonic, 3 to 1; fifth harmonic, 5 to 1, etc. When phase shift between signal harmonics and reference exists, the harmonic rejection will increase, i.e., less error results. However, low-pass filters may be sometimes necessary to eliminate the spurious effects of excessive odd-harmonic content.

The Model 302-1 AC TRVM, like all trio/lab ruggedized instruments, meets or exceeds the environmental performance requirements of MIL-T-945A and MIL-T-21200B, and its accuracy- temperature characteristics meet or exceed the requirements of MIL-M-10304A.

As one of the new line of trio/lab Build-In instruments designed to meet the specific requirements of equipment manufacturers, each instrument can be supplied in exactly those ranges and scales that are needed in the customer's application. Extra terminals can be provided to enable the use of the dc meter movement only for direct measurement of any dc current or dc voltage which does not require the high-impedance transistor voltmeter sensitivity or impedance. Series and shunt resistors may be inserted to provide multirange current and voltage measurements. This feature obviates the need for additional meters for such measurements, increasing the usefulness of the TRVM.—(*From new 25-page trio/lab catalog, Trio Laboratories, Inc., Plainview, L. I., N. Y.*)

FOR THIS LITERATURE CIRCLE 155 ON READER-SERVICE CARD

"Beam Miser" Electrode Ups BWO Tube Efficiency

A new "Beam Miser" design concept requiring no additional connections or power supplies to existing crossed-field oscillator and amplifier tubes has been developed by Raytheon's Spencer Laboratory (Burlington, Mass.).

The Beam Miser effect is accomplished by collecting a portion of the spent beam at cathode potential and returning it to the cathode via a conductor located inside the tube (Fig. 1). When the principle was designed into an M-type BWO, the oscillator was able to intercept as much as 40% of the total beam current. Return of this intercepted beam current to the cathode effectively increased the power output for a given power input (Fig. 2).

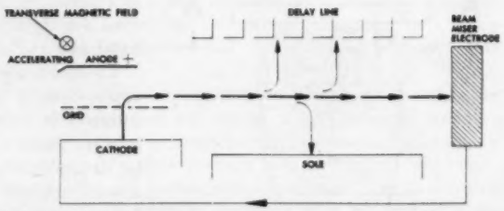


FIG. 1. "BEAM MISER" principle involves return of unused electrons from the spent beam via an electrode connected internally to the cathode. Tubes incorporating new improvement can be directly substituted in present circuits, gaining increased power, efficiency and bandwidth.

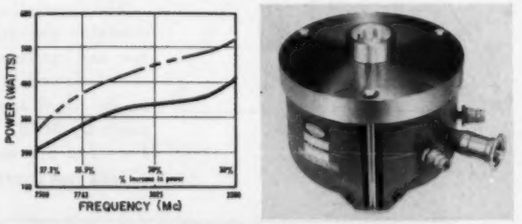
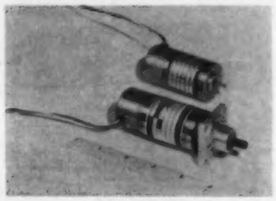


FIG. 2. DATA on "BEAM MISER" was obtained using Raytheon QK625 tube modified with internal electrode. Power output and efficiency with (dotted line), and without (solid line) "Miser" electrode is shown at right.

A further advantage of the Beam Miser principle, according to its developers, is that bandwidth is increased at given power levels. Tests show that no spurious signals nor deterioration of signal quality result from use of the Beam Miser. Further development is expected to provide additional improvement in power, efficiency and extension of the present 3-db bandwidth of crossed field amplifiers.

FOR THIS LITERATURE CIRCLE 156 ON READER-SERVICE CARD

WOUND FIELD MOTORS



New Type GJ wound field dc motors only 1⅜" in diameter are furnished in 1/50 hp (3" long) and 1/100 hp (2½" long), and normally in split-series field for reversibility with SPDT switch. Custom wound for specific application, shunt or split-shunt windings are also available.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton 4, Ohio.*

CIRCLE 157 ON READER-SERVICE CARD

PIEZOELECTRIC ACCELEROMETER

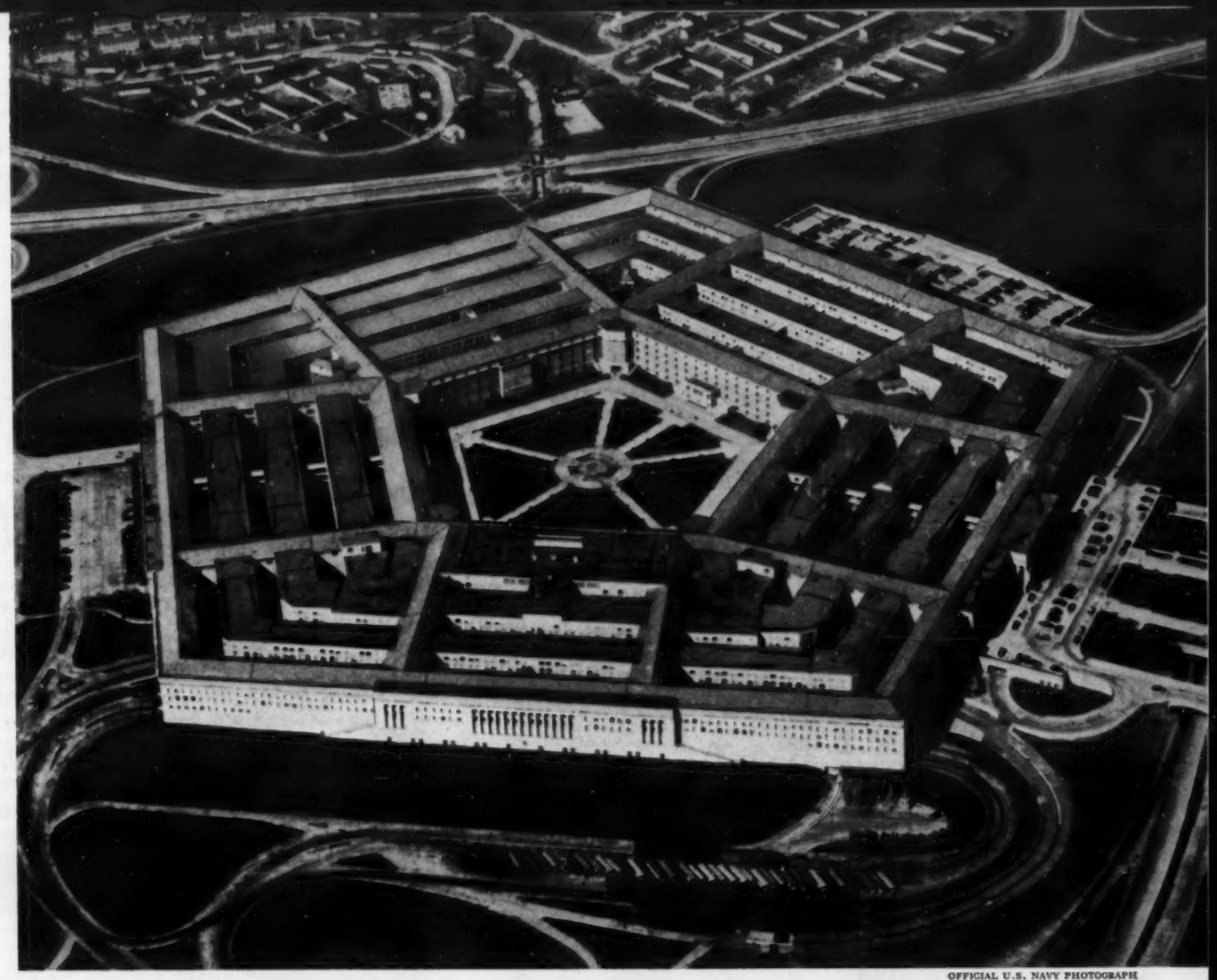
New miniature piezoelectric linear accelerometer Model AK105 featuring high natural frequency of 50 kc, small size, and rugged construction is designed to withstand stringent aerospace environmental requirements, giving 17 peak mv/G at room temperature, and operating from −65°F to +250°F.—*Statham Instruments, Inc.*, 12401 *W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 158 ON READER-SERVICE CARD

AC/DC TRANSDUCER ELEMENTS

Ac/dc rotary and linear signal generator elements for basic sensors in accelerometers, pressure transducers, rate gyros and rotation measurement in airborne servo systems feature infinite resolution, low reaction torque and low impedance. Data Sheet 120 on request.—*Giannini Controls Corporation*, 1600 *S. Mountain Ave., Duarte, Calif.*

CIRCLE 159 ON READER-SERVICE CARD



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Solid-State Pressure Switch

FIG. 1. SOLID-STATE switch, when open allows less than .8 ma to 600 ohm load with 28-v input; closed, 150 ma load produces a 2v max drop in switch.

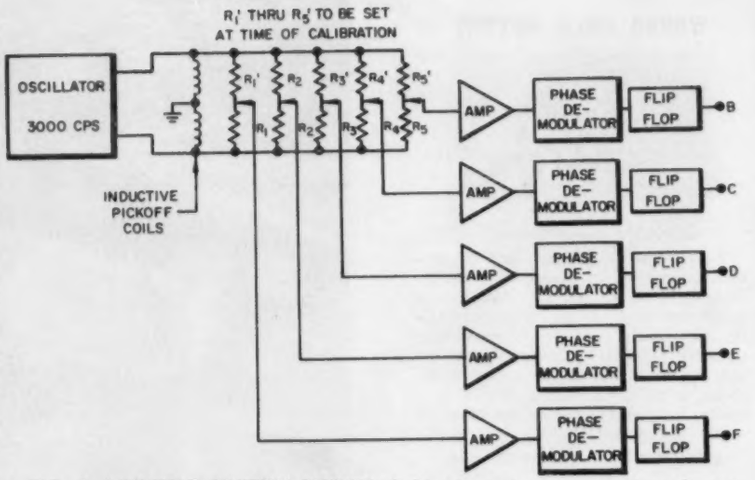


FIG. 2. MULTIPLE SWITCH POINTS, field adjusted over approximately one-third of full range, can be added in any number.

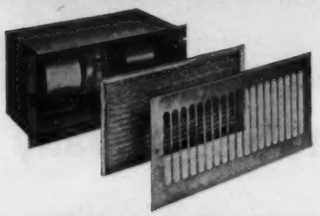
A new pressure switch for missile and other extreme environment applications has resulted from the marriage of solid-state circuitry with a twisted Bourdon tube. Designated the SM/I Type TR 2129, the solid-state switching function eliminates all moving parts and contact closures of conventional pressure switches, allows accurate and reliable operation under the environmental requirements of MIL-E-5400 and MIL-E-5272 (Fig. 1).

Dynamic stability is shown by the absence of chatter when pressure input is less than 0.5% of full scale pressure from the switch point although subjected to 60 G vibration and 100 G shock of 10 milliseconds duration. Pressure ratings from 0 to 5,000 psi, differential or absolute, are available. Only the Bourdon tube need be modified to achieve specified performance over any particular range, also additional switch points may be added without adding more pressure-sensing elements.

The TR 2129 accepts any gas or liquid, up to mildly corrosive types, which is free from large particles. It can also be furnished LOX compatible on request. On-off differential pressures can be as low as 0.1% up to 5% in standard production, but furnished as high as 70% on special request. The current switched is normally 0.15 amperes at 28 v dc ± 20% but can be increased to 2.0 amperes on special order. Additional data is available on request from the manufacturer, Servomechanisms, Inc., 200 N. Aviation Blvd., El Segundo, Calif.

FOR MORE INFORMATION CIRCLE 160 ON READER-SERVICE CARD

McLEAN



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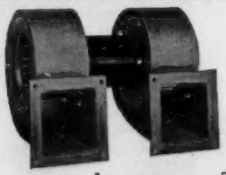

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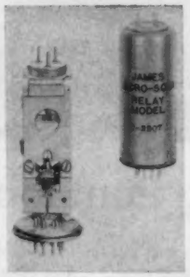
HIGH-SPEED RELAY



New 3PDT high-speed low-noise relay for sampling, multiplexing, time sharing and control circuits for low-level signals operates in 600 μsec. Rugged construction gives life expectancy of over 10^9 operations.—*James Electronics, Inc., 4050 No. Rockwell St., Chicago 18, Ill.*

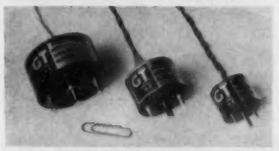
CIRCLE 161 ON READER-SERVICE CARD

LATCHING RELAY

New subminiature two-coil latching relay meeting Mil-Spec provides complete control of latching operation within itself, operates at a sensitivity of 150 mw/coil in an operating time of 5 msec at 25°C.—*C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.*

CIRCLE 162 ON READER-SERVICE CARD

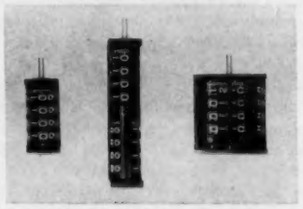
ROTARY SOLENOIDS



New rugged solenoids having true rotary motion without axial motion of shaft and designed for use in TIROS I and II are balanced against actuation by vibration or shock. Starting torques range from 1.5 oz-in to 65 oz-in.—*General Time Corporation, Central Research Laboratories, Progress Drive, Stamford, Conn.*

CIRCLE 163 ON READER-SERVICE CARD

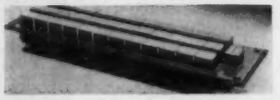
DIGITAL COUNTERS



New line of high speed, low torque, direct drive counters give plus and minus, right and left, or directional digital readings.—*Veeder-Root, Inc., 70 Sargeant St., Hartford 2, Conn.*

CIRCLE 164 ON READER-SERVICE CARD

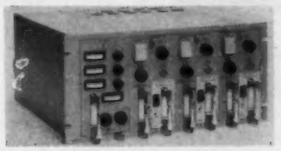
INTERLOCKED SWITCH PANEL



New 36-switch mechanically interlocked panel occupies only 16" x 4½" x 1¾" deep. Master release must be depressed before second key is actuated. Interlocking action can be varied to provide positive or momentary locking for rows or groups of keys to fit customer's needs.—*Pepco Incorporated, 2080 Placentia Ave., Costa Mesa, Calif.*

CIRCLE 165 ON READER-SERVICE CARD

PHASE-LOCK DISCRIMINATOR



New Model 0447 Telemetry Phase-Lock Discriminator utilizing the advantages of phase coherent detection, controls the tracking loop and output filter parameters by plugable selectors, available in several percentages of the total IRIG bandwidth for each channel.—*Hallamore Electronics Div., The Siegler Corp., 714 No. Brookhurst St., Anaheim, Calif.*

CIRCLE 166 ON READER-SERVICE CARD

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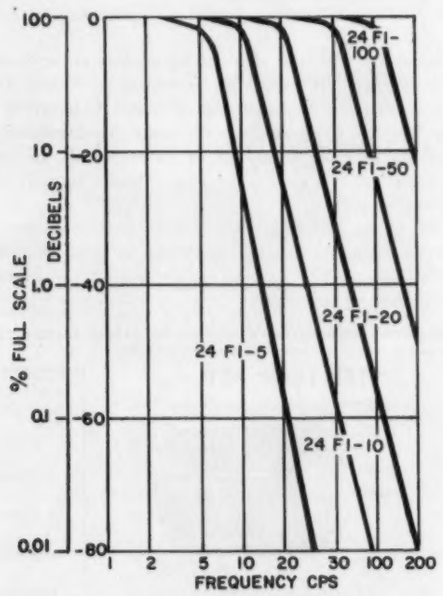
Solid-State Differential Amplifier

Designed for applications in digital processing where signal output lines are miles long—also for low-level analog instrumentation, preamplification and isolation for strip chart recorders, and laboratory bridge null detection—a new differential DC solid state amplifier now is available in six-channel racks or individual carrying cases.

The Neff Instrument Type 101B amplifier is engineered for extremely reliable amplification of low-level signals in the 0-100 cps frequency range.



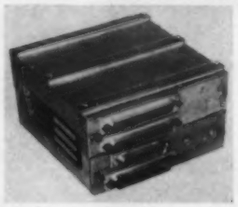
FILTER CURVES, Type 101B Amplifiers

Input impedance of the amplifier is greater than 1 megohm under all conditions of source impedance and gain setting, while the output impedance is less than ½ ohm. Its high slewing rate of 5000 volts per second insures that full scale output will be realized over the operating bandwidth of the amplifier under all load conditions.

Filter isolation is accomplished by low-pass plug-in filters internal to the amplifier which allow the band pass characteristics to be selected without affecting the input or output impedances of the amplifier. Filters having cut off frequencies of 5, 10, 20 and 50 cps are available and are directly interchangeable with the 100 cps filter included with each amplifier. Common mode rejection characteristics of each of the five filters are shown in the figure. (*From 4-page brochure 101B, Neff Instrument Corporation, 1088 E. Hamilton Rd., Duarte, Calif.*)

FOR THIS LITERATURE CIRCLE 167 ON READER-SERVICE CARD

STATIC MULTI SWITCH



New static transistor switch replaces multiple double-throw relays where environmental extremes preclude mechanical devices; provides 2, 4, 6 or 8 poles with isolation resistance to 50 megohms in off condition, conductive resistance of 50 ohms in on condition.—*Applied Electronics Corp., of N. J., 22 Center St., Metuchen, N. J.*

CIRCLE 168 ON READER-SERVICE CARD

STANDARD MICRO RELAY

New 4-PDT microminiature relay Type JH-12 rounds out standardized relay family with standard contact configurations (0.2" grid spaced) for 2-, 4- and 6-pole types. Contacts are rated at 2 amps noninductive, 29v dc or 115v ac. Low-level contacts tested to 10,000 operations on "miss-test" are also available. Full specifications on request.—*Allied Control Company, Inc., 2 East End Ave., New York 21, N. Y.*

CIRCLE 169 ON READER-SERVICE CARD

PROGRAM CONTROLLER

New Tenor Model 120 program controller consists of drum mounted adjacent to a row of switches. The drum is stepped through 360° in 60 steps, holding on each step until signalled to advance. Programs are quickly changed by relocating the pins or by interchanging pre-programmed drums, which then become memory units, remembering control function for later use.—*Tenor Company, 13460 W. Silver Spring Drive, Butler, Wisc.*

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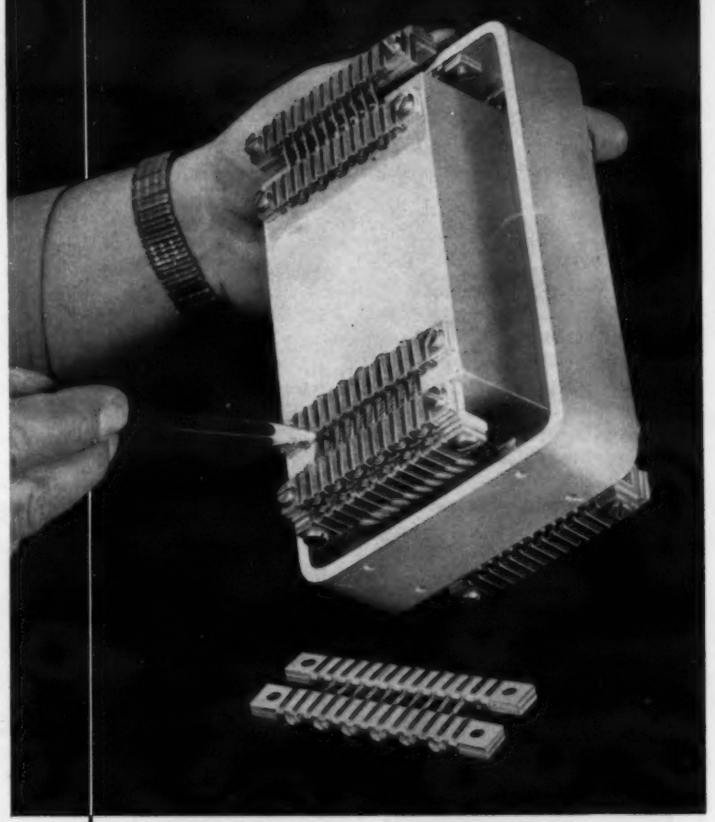
DETUNE VIBRATION ISOLATE SHOCK

From Aeroflex Laboratories—a major development in the control of vibration and shock—the all new field-proven Cable Isolation System.



NOW YOU CAN:

- Isolate your equipment against shock, vibration and noise, or any combination thereof—even in the presence of constant or long term "G" loading.
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ANALOG COMPONENT

Solid-State Analog Multiplier-Divider

FIG. 1. COMPUTER Element—solid-state device replacing instrument servo—is only 2⅛" x 2¼" x 5".

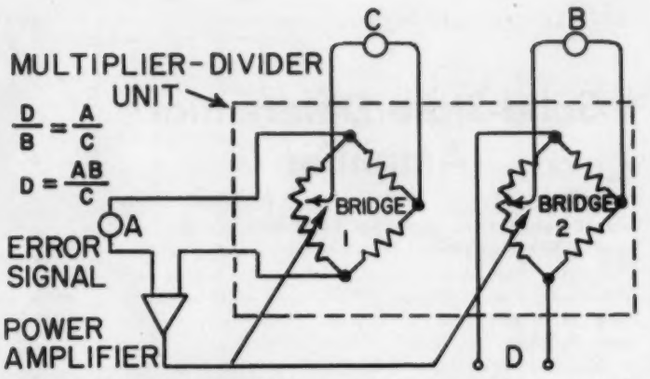


FIG. 2. MAGNETORESISTIVE Elements in each Bridge are equally affected by output of power amplifier.

A new development of Elasco, Inc., Boston 19, Mass. using solid-state techniques is said to execute the operation:

$$D = \frac{AxB}{C}$$

with an accuracy better than 0.1%. Designated the MD-101 the new device is capable of performing the functions of a servomechanism with high accuracy although it has no moving parts. Bandwidths match or exceed those obtainable with good electromechanical servomechanisms. Exceptionally compact and rugged, the MD101 is particularly suited for military applications and severe environmental conditions.

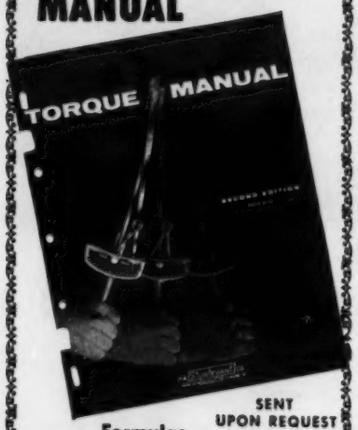
The Elasco MD101 unit consists of a basic computing element (Fig. 1), and a power amplifier. The computation element is an array of solid state resistors set up in two bridge circuits (Fig.2). The dc output of the power amplifier controls a magnetic field which affects magnetoresistive elements of the bridge, making the device the functional equivalent of a servomechanism. The versatility of the device is enhanced by complete isolation between the separate bridges.

Because the parameters A and C are completely isolated (and may differ in form from B and D) ac and dc signals may be mixed in the computation with no loss in accuracy. The unit also can be used as an ac-to-dc (or dc-to-ac) converter of high accuracy, providing ripple-free dc output without the use of filters. Converting from one frequency to another is easily accomplished and squaring is a simple matter of letter A = B. Extracting the square root is an inverse process requiring only an additional amplifier.

The power amplifier, which provides the control current, is available as a vacuum-tube or solid-state device and its design will vary to a degree with the particular application of the device.

FOR MORE INFORMATION CIRCLE 171 ON READER-SERVICE CARD

"TORQUE WRENCH" MANUAL



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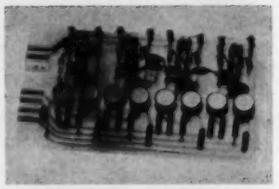
PLUG-IN DECADE COUNTER



New DCU-100 solid-state decade counter with diode steering resets to zero at every tenth pulse, while providing output pulse to drive next DCU-100 unit. Any number of plug-in units can be cascaded.—*Components Corporation, 106 Main St., Denville, N. J.*

CIRCLE 172 ON READER-SERVICE CARD

ULTRAMIN TRIMMING POT

New 200 Series Squaretrim® subminiature precision pot, ⅜" square by 0.140" thick, available in values from 10 ohms to 50 kohms, uses machined aluminum case for high dissipation rating of 1 watt in still air. Operates over −55° to 150°C range.—*Potentiometer Div., Daystrom, Incorporated, Archbald, Pa.*

CIRCLE 173 ON READER-SERVICE CARD

TIME CODE GENERATOR

New EECO 811 Time Code Generator for supplying IRIG formats A, B, C, and D plus parallel code output, 10 pps and lpps sync pulses features frequency stability to 1 part in 10^8/day, all solid-state card construction and operates on 115 v ac, 50-400 cps.—*Electronic Engineering Co. of California, 1601 East Chestnut Ave., Santa Ana, Calif.*

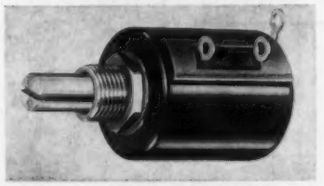
CIRCLE 174 ON READER-SERVICE CARD

MIL-TYPE CONTROLS

New miniature composition controls meeting MIL-R-94B, Stype RV1, are rated at 1/5 watt at 70°C derated to zero at 120°C. Values range from 500 ohms to 1 megohm linear taper and are available in standard and locking bushings as shown.—*Centralab, The Electronics Div., of Globe-Union Inc., 900 East Keefe Ave., Milwaukee 1, Wisc.*

CIRCLE 175 ON READER-SERVICE CARD

TEN-TURN POT



New 10-turn Model 3500 precision potentiometer offers 20% longer resistance element in case only ⅞" dia x 1" long. Meets cycling humidity test of MIL-STD-202B Method 106; resolution is 0.03 to 0.01%.—*Trimpot Div., Bourns, Inc., 6135 Magnolia Ave., Riverside, Calif.*

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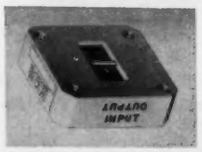
COMPACT ATTENUATOR



New X-Band attenuator with only ½" insertion length provides 10 db with an input VSWR of 1.15 max. Molded-in attenuating element provides up to 1 watt CW dissipation over the 8.5 to 9.6 Gc range and in ambients from −55° to 160°C.—*Microwave Components and Systems Corp., Monrovia, Calif.*

CIRCLE 177 ON READER-SERVICE CARD

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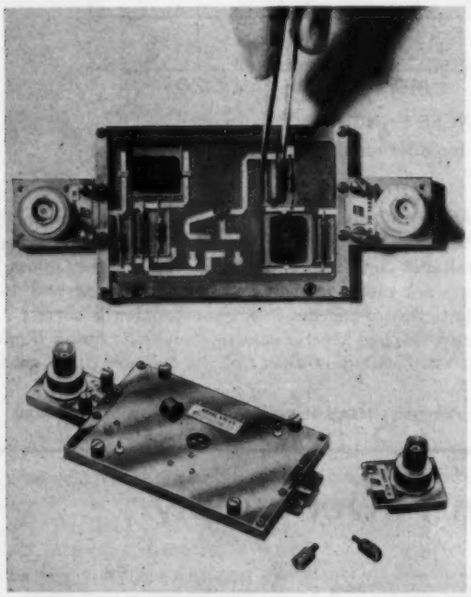
Microwave Circuit Evaluates High Frequency Transistors

Evaluation of high frequency transistors at UHF and microwave frequencies has long been difficult and expensive because of the critical nature of circuit construction at these frequencies. A new universal transistor Circuit-Mount in Tri-Plate® Strip transmission line is now available which increases the reliability of such evaluations while cutting their costs in technician time and material.

The unique design, as shown in the "cover off" view,



provides eight special cavities for insertion of standard lumped components such as resistors, capacitors, inductors and diodes. Conductor strips are supplied to short out unused cavities, enabling the formation of an almost unlimited number of different circuits. Very fast rise times and excellent control of line impedances are claimed for the technique by its developer, Sanders Associates, Inc., 95 Canal St., Nashua, New Hampshire.

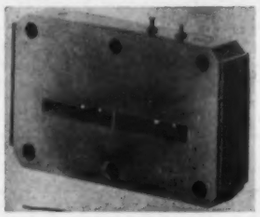
Four standard models using 50 ohm Tri-Plate Module male connectors are available:

MU-11 for short-lead transistors with TO-5 cases
MU-12 for short-lead transistors with TO-18 cases
MU-21 for long lead transistors with TO-5 cases
MU-22 for long lead transistors with TO-18 cases

Transitions to all popular coax connectors are also available.

FOR THIS LITERATURE CIRCLE 178 ON READER-SERVICE CARD

WAVEGUIDE SHORTING SWITCH



New shorting switch for WR90 Dual Waveguide have a switching time of only 10 msec. Normally closed switches are unaffected by external magnetic fields, permitting their use near ferrite and other magnetic devices.—*Microwave Development Laboratories, Inc., Natick, Mass.*

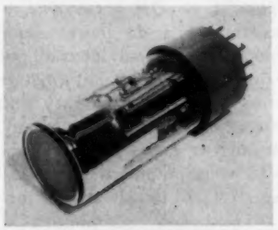
CIRCLE 179 ON READER-SERVICE CARD

LOW-NOISE KLYSTRON

New Model VA-511, 50 watt 10 gigacycle low-noise oscillator is typical of a new line of klystrons suitable for use in CW illuminators, fixed-frequency doppler navigation transmitters, etc., The new fixed-frequency, two-cavity oscillator has an FM noise figure less than 1 cycle, and is electrostatically focussed. —*Tube Division, Varian Associates, 611 Hansen Way, Palo Alto, Calif.*

CIRCLE 180 ON READER-SERVICE CARD

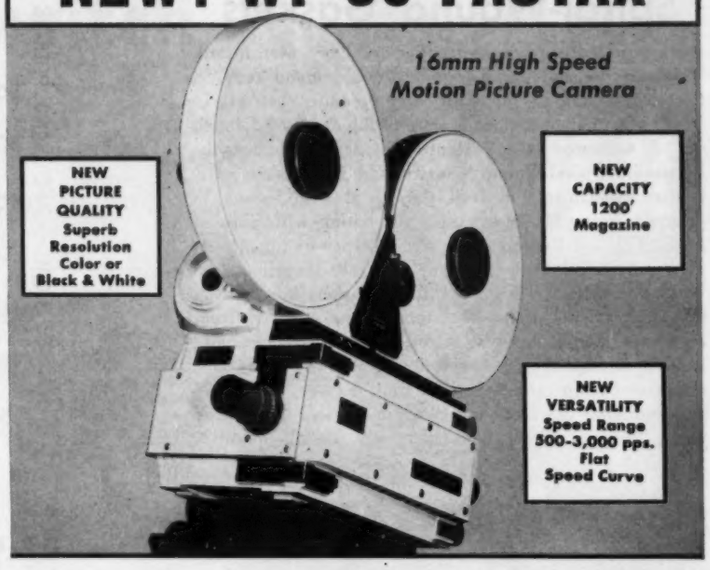
TRI-ALKALI PHOTO TUBES



New multiplier phototubes using the tri-alkali photosensitive surface (S-20) include the 2" K1927, 3" K2167, and the 5" K2173, with development proceeding to extend tri-alkali surfaces to all existing multiplier phototube sizes. Increased sensitivity in white light spectrum is said due to extension of red response out as far as 8000 Angstroms. Also dark current is lower than with usual S11 surface. —*Allen B. Du Mont Laboratories, 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 181 ON READER-SERVICE CARD

NEW! WF-30 FASTAX



Years Ahead in Design and Performance

A high speed camera with large film capacity . . . with a variety of speed ranges and high resolution has long been wanted by industry, the military and the government. The FASTAX WF-30 fills all these requirements and more. Darkroom loaded, "T" core, the magazine holds sufficient film for most studies. Camera versatility is another key feature. Variable speed range, controlled by a solid state loop servo device . . . rapid acceleration with flat speed curve within ±4% selected rate . . . start-stop capabilities. Superb resolution over entire frame results from excellent lens system and a sector shutter between rotating prism and focal plane.

WRITE for complete information and prices on WF-30 . . . the newest FASTAX in the wide line of Wollensak high speed motion picture cameras.

WF-32 OSCILLOGRAPHIC RECORDER

Wollensak AN AFFILIATE OF 3M COMPANY
850 Hudson Ave. • Rochester 21, N.Y.
MINNESOTA MINING AND MANUFACTURING COMPANY

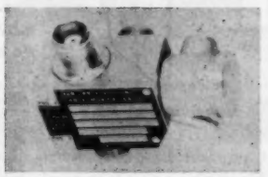
CIRCLE 49 ON READER-SERVICE CARD

TIMING MODULE

New 7-oz solid-state electronic timing module, capable of switching either a positive or negative voltage, is remotely adjustable from 1 minute to 4 hours at 5% accuracy, can be supplied for operation from 10 to 32 v dc, and supplies 100 ma inductive or resistive output. Meets MIL-E-5272C specifications.—*Electronic Products Corp., 4642 Belair Rd., Baltimore 6, Md.*

CIRCLE 182 ON READER-SERVICE CARD

MICROWAVE SWITCH



New version SA-90 SPDT microwave switch has improved RF cavity design permitting operation up to 6 Gc. Can be furnished for 28v dc or 115 vdc 60 or 400 cps actuation or other power on special order.—*Don-Lan Electronics Inc., 1131 Olympic Blvd., Santa Monica, Calif.*

CIRCLE 183 ON READER-SERVICE CARD

Application of Spiral-Wound Gaskets

High-pressure steam, hydraulics and gases used in military, marine and missile applications demand reliable, effective sealing of joints in high pressure systems. In 1912, when flange standards were of the order of 250 psi, 400°F saturated steam, Henry Bohmer originated the Flexitallic Spiral-Wound construction for gaskets. Repeated experiments evolved the spiral winding of V-crimped spring-like metal plies alternating with plies of filler (Fig. 1). Properties of metals, types of fillers, and their interrelationship—became controlled variables in Flexitallic design. Today, Flexitallic gaskets are meeting the requirements of modern applications widened from steam to liquids, fuels, atomic power systems, etc., and ranging beyond the present flange standards of 2500 lbs, with super temperatures beyond 1500°F.

When joint assembly is placed in service, three basic forces become active and affect its sealing qualities (Fig. 2).

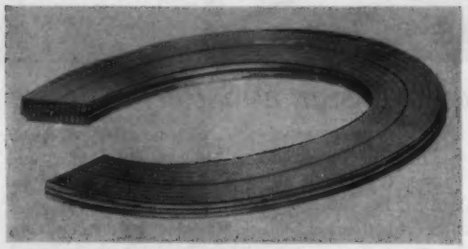


FIG. 1. TYPICAL FLEXITALLIC construction. V-crimped spring metal plies alternate with plies of non-metallic fillers.

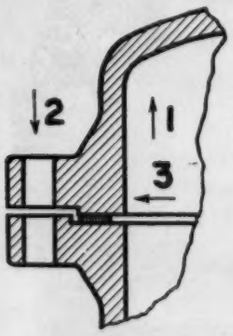


FIG. 2. THREE VARIABLES affecting sealing qualities of a gasket: (1) End Force—tends to separate the flange faces; (2) Gasket Load—Applied by bolting or other means to flanges to compress the gasket; and (3, Internal Pressure—tending to move, permeate or bypass the gasket.

Because these forces are operating variables in any joint assembly, a gasket of resilient construction, such as the Flexitallic construction, is more suitable in adapting to the three variable forces than one of solid construction which cannot adjust to varying conditions.

How the design of a gasket varies with one of the parameters, gasket load, is illustrated in Fig. 3. A Flexitallic Style CG gasket for use with a 6" raised face flange assembly is described. For each pressure series considered, the gasket area is the same, but the bolting varies.

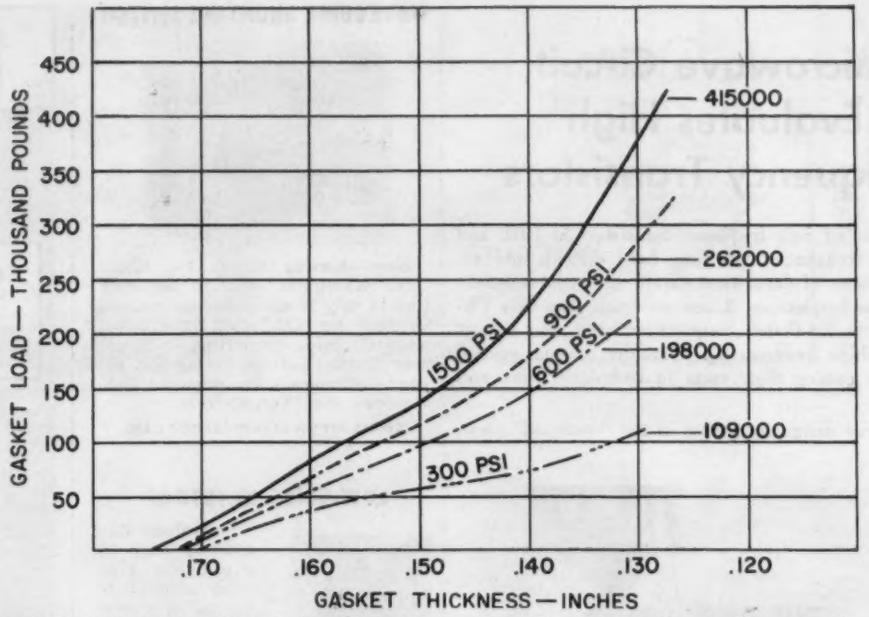


FIG. 3. COMPARISON of Gasket Characteristics for different pressure series, for 6" Style CG Flexitallic Gasket.

With bolting calculated at a constant stress of 30,000* psi the resulting gasket loads vary as shown on the graph. A constant terminal thickness is retained within the limits of the gasket body by designing a specific construction for each case. This design is determined by Flexitallic engineers and for this reason they must be furnished with complete and accurate flange and load data to insure that the gasket construction is correct . . . (*From 30-page general catalog, Flexitallic Spiral Wound Gaskets, Flexitallic Gasket Co., 8th & Bailey Sts., Camden 2, N. J.*)

FOR THIS LITERATURE CIRCLE 184 ON READER-SERVICE CARD

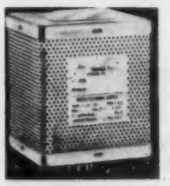
*Stress of 30,000 psi is well within the yield point of low alloy bolting but is sometimes equal to or above the yield points of 18-8 Cr Ni and other austentic steels. When low yield point metal is used for flanges or bolts special gasket construction may be necessary and Flexitallic engineers should be consulted.

Transistorized Plug-In Power Supply

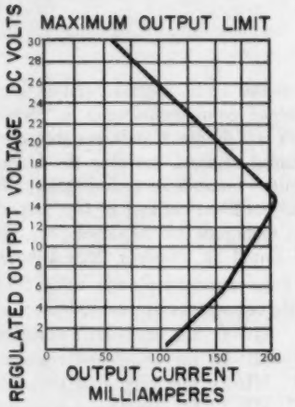
A new line of transistorized ac-dc power supplies feature voltage adjustments either from internal potentiometer or remote external pot. Model T030 (pictured) uses a 30,000 ohm across pins 5 & 6 to vary output voltage from 0 to 30 v dc, as shown in the accompanying graph. Maximum output current varies from 100 ma to over 200 ma at about 15 volts output, then diminshes linearly with increasing voltage to about 60 ma at 30 volts output.

Input voltage of the supplies is 105-125 vac, 60 to 400 cps single phase. Line and load regulation are both ±0.5% and ripple is 0.1% maximum. Series T supplies, shown, are 3¼" x 3⅜" x 4 7/16", weigh 2 lbs, supply outputs from 8 to 30 volts and current ratings from 50 to 200 ma. Series M supplies are one inch higher, weigh one-half pound more, and supply outputs from 9 to 40 volts and current ratings of 500 to 700 ma. Ripple is only 1 mv rms max. . .(*From 4-page brochure, Acopian Technical Company, 927 Spruce St., Easton, Pa.*)

FOR THIS LITERATURE CIRCLE 185 ON READER-SERVICE CARD



PLUG-IN Supply units feature voltage adjustments by internal pot or remote external pot.



High Speed RF Gate/ Switch

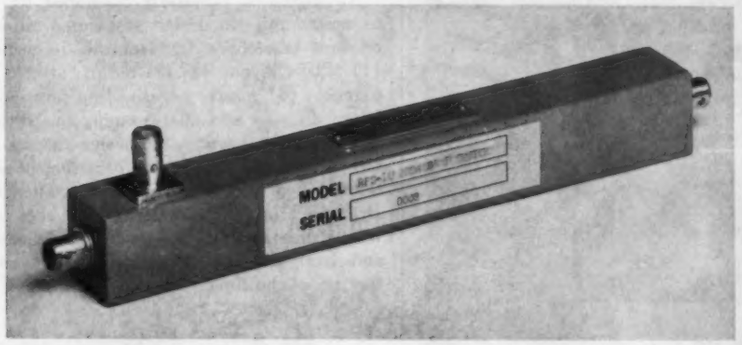
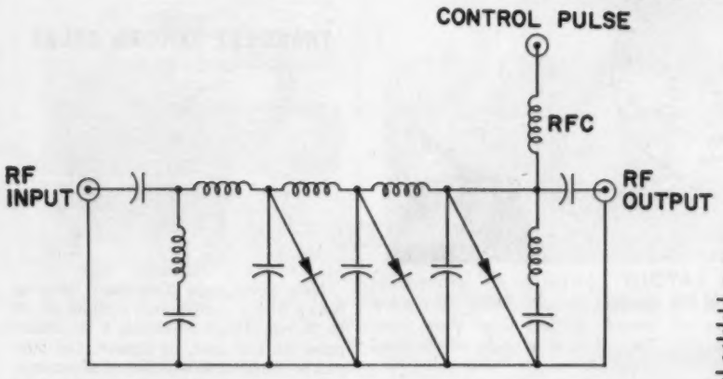


FIG. 1. RF GATE SWITCH with high speed characteristics is shown with simplified schematic diagram.



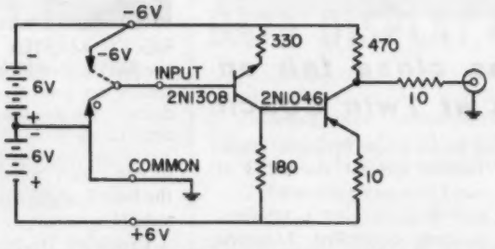


FIG. 2. TRANSISTORIZED driving circuit for switch.

A broadband RF electronically-gated switch operating with switching times in the order of 0.2 μsec is a development of the RMS Engineering, Inc., P.O. Box 6354, Station H, Atlanta 8, Ga.

Essentially a low-pass filter with a cut-off above 400 mc, each section has a point contact diode in shunt (Fig. 1). In their normally back-biased state the diodes serve only to add a small capacitance, absorbed in the filter design. In this "closed" state, the filter presents a very small insertion loss (approximately 1 db).

By applying forward bias to the diodes each filter section is shunted with a low resistance and very high attenuation (about 60 db) resulting from the severe impedance mismatch puts the switch into an "open" condition. Because most of the incident power is reflected, little RF energy enters the filter to be dissipated by the diodes.

A simple transistorized driving circuit for the switch but not included in the unit is shown in Fig. 2. Typical performance characteristics for the switch are shown in Fig. 3. The Model RFS-LU switch operates at any frequency in the 50-400 mc range, with input and output (closed) impedances of 50 ohms. Its size overall, excluding BNC fittings, is only 1" x 1" x 8" long.

CIRCLE 186 ON READER-SERVICE CARD

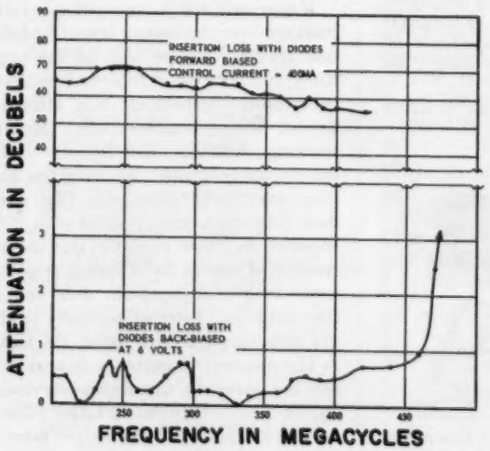
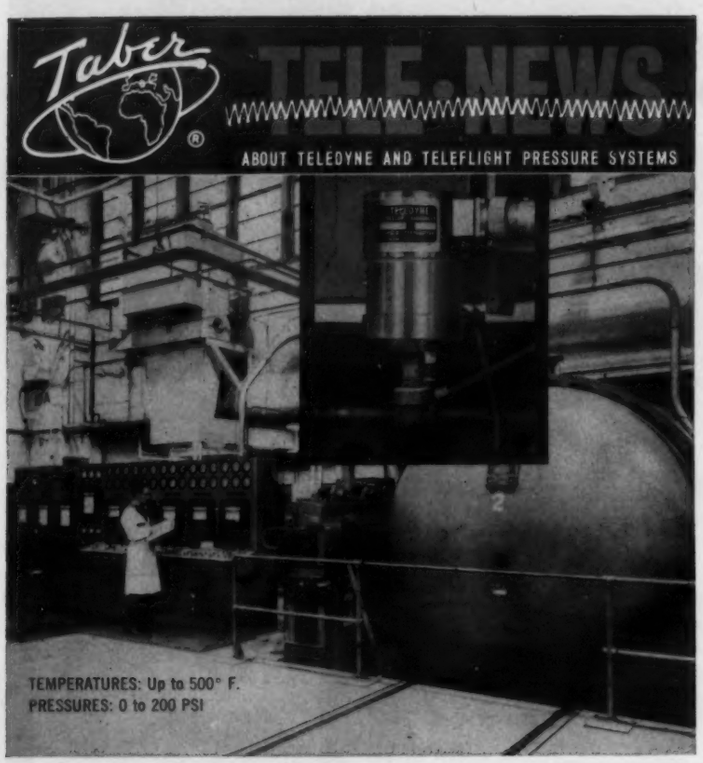

INSERTION LOSS WITH DIODES FORWARD BIASED CONTROL CURRENT = 40MA
INSERTION LOSS WITH DIODES BACK-BIASED AT 6 VOLTS
ATTENUATION IN DECIBELS
FREQUENCY IN MEGACYCLES

FIG. 3. INSERTION LOSS, open condition (upper curve) and closed condition (lower curve).

D-C POWER
Up to 1500 Amperes
Over 200
Rectifier Power Supplies
Automatic Battery Chargers
in these 6 Types
SILICON CONTROLLED RECTIFIER
TRANSISTOR-MAGNETIC AMPLIFIER
MAGNETIC AMPLIFIER (STAVOLT)
UNREGULATED AND SEMI-REGULATED (RECTODYNE)
ALL TRANSISTOR
AUTOMATIC BATTERY CHARGERS FOR EVERY TYPE OF BATTERY
CHRISTIE
Write for Complete Information
CHRISTIE ELECTRIC CORP.
3412C West 67th Street
Los Angeles 43, California
CIRCLE 50 ON READER-SERVICE CARD



Taber Transducer keeps close tab on autoclave air pressures at Twin Coach

The dependability and accuracy of Taber Bonded Strain Gage Pressure Transducers are pointed up in the manufacture of bonded aircraft assemblies at Twin Coach Co., Buffalo, N. Y.

Assemblies are bonded at temperatures up to 500° F inside a 12′ x 37′ autoclave where atmospheric conditions must be precisely controlled. Mounted externally to permit this high temperature application, a Taber Model 217 Teledyne Pressure Transducer senses autoclave air pressures from 0 to 200 psi, accurately and continuously. *Quality of manufacture is thus insured!*

Among the many performance pluses of Taber Transducers are high frequency response, minimum hysteresis, infinite resolution and low sensitivity to temperature effects, vibration and shock. Models are produced for a wide variety of test, ground support, or airborne applications, with pressure ranges from 0-50 to 0-10,000 psi.

For detailed information on Taber Transducers, mail this coupon attached to your letterhead.

TO: TABER INSTRUMENT CORPORATION
AEROSPACE ELECTRONICS DIVISION SECTION 242
107 Goundry Street, North Tonawanda, N. Y.

Send detailed information on Taber Teledyne and Teleflight bonded strain gage pressure transducers.

name _____ title _____

company _____ dept. _____

address _____

city _____ zone _____ state _____

CIRCLE 51 ON READER-SERVICE CARD

Photographic Techniques Speed Printed Circuit Production

An improved procedure developed by Bendix-Pacific to assure uniform design of printed circuit boards and relevant assemblies involves the following documents: (1) Master layout, (2) master artwork, (3) master transparency, (4) master negative and positive, (5) machine board drawing and (6) assembly board drawing.

The *master layout* is the basic drawing. Containing all mechanical and electrical information needed to produce the finished printed circuit, it is drafted on Cronaflex® Drafting Film by the designer from sketches, schematics, wiring diagrams and other data furnished by mechanical and electronic engineers. This drawing is made four times the size of the finished board to minimize the magnitude

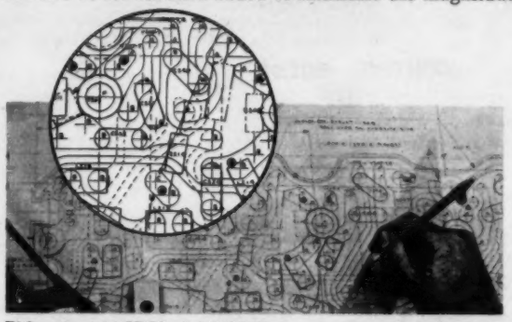


FIG. 1. MASTER LAYOUT contains all information needed to produce the printed circuit. Solid lines show circuit on one side of board; dotted lines show conductors on reverse side. Layout is 4 x scale of finished circuit.

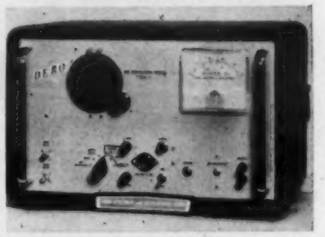
of any error. Solid lines show the circuit on one side of the board; dotted outlines show conductors on the reverse side (Fig. 1).

Cronaflex Drafting Film is used for layout because of its ability to hold size under varying temperature and humidity conditions, and because of its superior drafting surface.

Master artwork is prepared by placing a sheet of Ruby Studnite over the master layout and the circuit configuration traced for each side of the printed circuit board. Ruby Studnite is a two-layer material consisting of a ruby-colored translucent film affixed to a tough, transparent, dimensionally stable "Mylar"® film base. In working with this material, the draftsman cuts around the circuit contours, removing the background by stripping away superfluous ruby film (Fig. 2). Said to produce a more accurate document in 20% to 33% the time required by other methods, this method allows easy correction of errors by affixing a piece of artist-aid material over a stripped-out area and cutting in the new configuration. Letters, numbers and dimension marks are also supplied with artist aid materials.

The *master transparency* is next made by photographing the artwork, simultaneously reducing the scale by ½, on Cronar® Ortho A Litho Film—.004″ thick—and from it a contact *positive* on the same material. This posi-

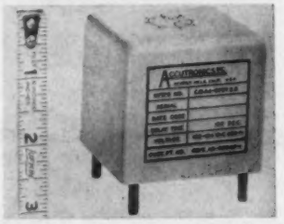
FM DEVIATION MONITOR



New FM Deviation Monitor Model DM-4A low sensitivity FM receiver employing a stable counter type discriminator where the demodulated signal is displayed on a direct reading deviation meter. It measures and analyzes FM signals in the Missile Range Command band of 400 - 550 mc to a calibration accuracy of 1%.—*Dero Research & Development Corp., Broadway & Park Ave., Huntington, N. Y.*

CIRCLE 187 ON READER-SERVICE CARD

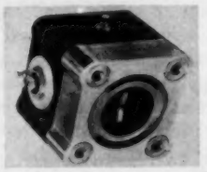
TRANSIENT SENSING RELAY



New Solid-state Transient Sensing Relay has a continuous output of 12 to 28 vdc. Upon receiving a transient pulse of 100 μsec, or longer, the output is changed to a pulse of .5 seconds ON, .5 seconds OFF, for a period of 10 seconds and then returns to a continuous output. The output circuit is rated at 500 ma continuous load.—*Accutronics, Inc., 403 No. Foothill Rd., Beverly Hills, Calif.*

CIRCLE 188 ON READER-SERVICE CARD

VARIABLE ATTENUATORS



Four new Calibrated Variable Attenuators in two type styles include: Type 1 (MA-527A and MA-670) controlling attenuator vane by an anti-backlash calibrated micrometer mounted atop the control box; and Type 2 (MA-580A and MA-587) in which the attenuating vane is controlled by a spring-loaded knob-driven tuner with a locking device.—*Microwave Associates, Inc., Burlington, Mass.*

CIRCLE 189 ON READER-SERVICE CARD

tive is superimposed on a master format containing title block and references, and a direct positive reproduction made on Cronaflex Direct Positive Film, also .004" thick. This is the *master transparency* (Fig. 3).

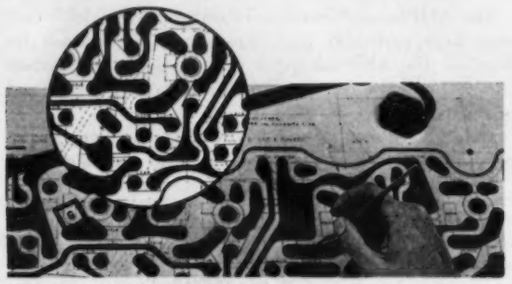


FIG. 2. MASTER ARTWORK is prepared by stripping away background from outlines traced on Ruby Studnite®, leaving conductors in red.

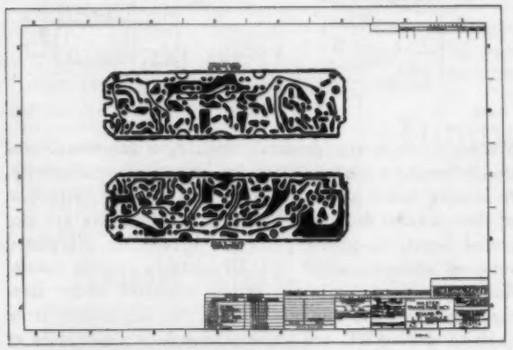


FIG. 3. MASTER TRANSPARENCY is art work reduced one-half, with title block and references.

From the *master transparency* are made all subsequent photo reproductions, thus it must incorporate any final changes in circuit configuration. It serves in place of the master artwork when further drafting or detailing is subcontracted.

The *master negative* is next made, using a 50% photo reduction down to 1:1 circuit board scale, holding the negative to .005" of specified dimensions between tooling marks. The master positive is a direct contact print of the negative, both being produced on Cronar Ortho A Litho Film—.007" thick—for maximum dimensional stability.

The master negative is used to expose the copper-clad laminated board; the master positive to make multiple negatives by the step-and-repeat method. Both the master negatives and positives are used as quality control tools, serving to check completed boards for hole alignment, dimensional stability, peripheral and trim lines. *Machine Bond* and *Assembly Bond* drawings are also made from the Master Transparency. These are 2:1 scale positives to accommodate machinery data and assembly directions . . . (*From article by E. E. Benjamin, S. B. Ballard, and H. A. Gray, of Bendix-Pacific Div., The Bendix Corporation; in 8-page Dupont Cronaflex Applications Bulletin, Photo Products Dept., E. I. DuPont De Nemours & Co. (Inc.), Wilmington 98, Del.*)

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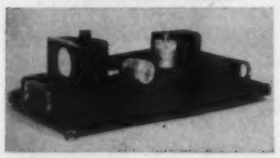
FOR THIS LITERATURE CIRCLE 190 ON READER-SERVICE CARD

MICRO-POSITIONER



New Model 397 Micro-Positioner is an optical-mechanical instrument for measuring the minute angles in two axes required by inertial guidance systems, infrared trackers, theodolites and rotatable mounts used in military systems. Temperature compensated mechanical linkages; 0.1 sec/div micrometers are used.—*OptoMechanisms, Inc., Engineers Hill, Plainview, L.I., N. Y.*

CIRCLE 191 ON READER-SERVICE CARD

PRECISION LIMIT STOP

New mechanical stop permitting settings from 0 to 100 turns measures only ⅞" long, uses hardened pins which make radial contact at only ⅛th of input speed. Corrosion resistant materials used throughout.—*Dynamic Gear Co., Inc., Amityville, N. Y.*

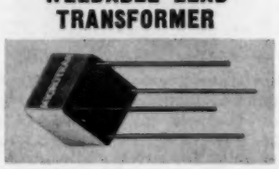
CIRCLE 192 ON READER-SERVICE CARD

VISCOUS DAMPED MOTOR

New Model R180-001 Size 11 viscous damped servo motor provides high damping and/or low time constants for instrument applications. Minimum stall torque, 0.60 oz-in; no-load speed, 1700 rpm ;weight, 6 oz.—*Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N. J.*

CIRCLE 193 ON READER-SERVICE CARD

WELDABLE LEAD TRANSFORMER



New miniature transformers feature gold-plated nickel-iron alloy leads for superior weld joints in hi-density electronic assemblies. Catalog on request.—*Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N. Y.*

CIRCLE 194 ON READER-SERVICE CARD

MINI-RAPID PROCESSOR DEVELOPS DATA DISPLAY FILM RECORDS–FAST!

See your data display film records in minutes. Fairchild Mini-Rapid Film Processors give you automatic delivery of negatives – developed, fixed, washed, dried—commercial quality.

16mm films up to 6 f.p.m.

35mm films up to 4 f.p.m.

Oscillograms, digital or analog display, radar, meters, gauges, controls – any information display that you record on 35 or 16mm film can be read back just a few minutes after your film is inserted into the Mini-Rapid.

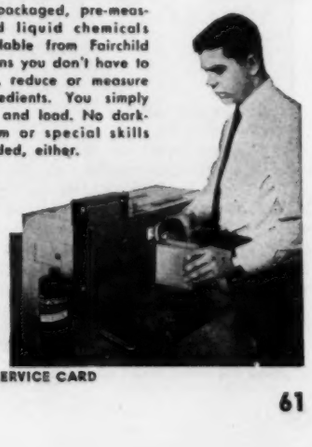
Operation? Easy. Insert a few inches of film into the loading compartment, drop in spool, close door. Automatic transport takes over and does the rest.

Write for illustrated specifications and prices to Industrial Products Division, Dept. MS-12, Fairchild Camera and Instrument Corp., 580 Midland Ave., Yonkers, N. Y.

MINI-RAPID FEATURES

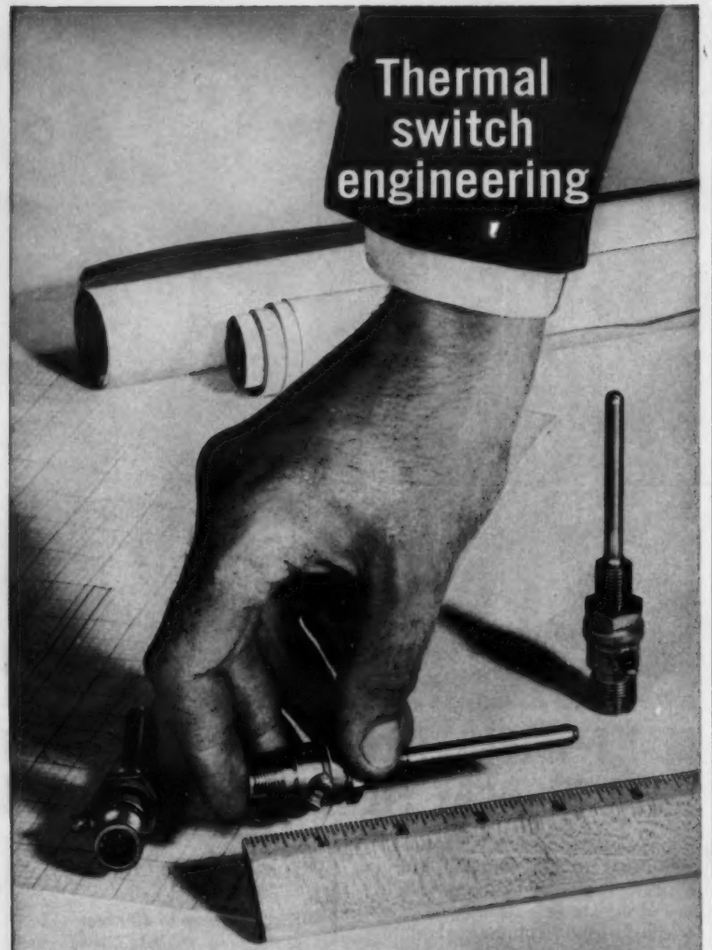
- capacity up to 400 feet
- table top compactness
- dual thermostat control
- completely automatic
- leaderless daylight loading
- self-threading film transport

Pre-packaged, pre-measured liquid chemicals available from Fairchild means you don't have to add, reduce or measure ingredients. You simply mix and load. No darkroom or special skills needed, either.



INDUSTRIAL PRODUCTS DIVISION
FAIRCHILD
CAMERA AND INSTRUMENT CORPORATION

CIRCLE 52 ON READER-SERVICE CARD



CPI RESEARCH CREATES A NEW "SHORT HEAD" SWITCH

From CPI research comes this new thermal switch with the shortest head construction of any AN connector type switch. This hermetically sealed, field adjustable, probe type switch was developed for an aircraft manufacturer to control inlet air temperature for heating and turbine exhaust temperatures for air conditioners.

There are other uses, too—controlling temperatures of gas turbines and heat exchangers or oil in gear boxes—in fact, many places where there's need for a hermetically sealed switch with a fast, easy electrical connection. It is possible that this or the many others developed by CPI specialists may not solve your problem. If not, CPI research can create the switch that will! Send your specs.

This new switch is constructed of all high temperature alloys and has a calibration range of −20F to 1750F with safe momentary overshoot to 2000F and undershoot to −100F. It is available in a variety of threaded and plate mountings. Mention "Spec-Stat" when inquiring.

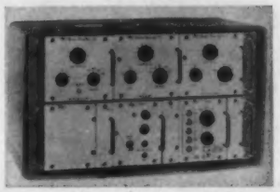
CPI

CONTROL PRODUCTS, INC.

274 Ridgedale Ave. • Hanover, N.J.

CIRCLE 53 ON READER-SERVICE CARD

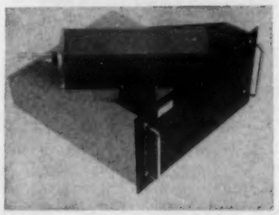
PULSE GENERATOR



New Model 4550A modular pulse generator provides variable test pulses with rise times of 10 nsec at rep rates to 10 mc for use in development and test of circuits, components and digital systems. Details on solid-state construction and modular versatility on request.—*Servo Corporation of America, 111 New South Rd., Hicksville, L.I., N. Y.*

CIRCLE 195 ON READER-SERVICE CARD

LOW-NOISE AMPLIFIERS



New WJ-111 and WJ-112 ultra low-noise packaged wideband amplifiers cover the 2-4 kmc and 1 to 2 kmc regions with typical noise figures of 4.3 and 4.0 respectively. Units operate from Type 180 power supply, include appropriate tube, solenoid, and solenoid blower.—*Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif.*

CIRCLE 196 ON READER-SERVICE CARD

REMOTE CONTROL RECEIVER

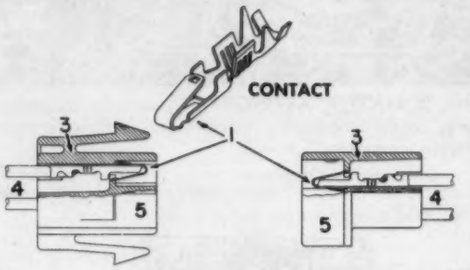
New transistorized receiver-decoder accommodates up to 20 IRIG command channels in the 406-549 mc range. Each channel operates a 2 amp SPST relay for functional control instructions. Up to six channels can operate simultaneously from 10 μv signals. Frequency stability is within 0.01%.—*Babcock Electronics Corp., 1640 Monrovia Ave., Costa Mesa, Calif.*

CIRCLE 197 ON READER-SERVICE CARD

Multiple Circuit Connectors

The AMPin-cert® connectors utilizing AMP-lok® contacts have particular applications in the electronic industries. The AMP-lok quick connect/disconnect feature allows for easy, economical performance checks and maintenance.

Leading features of the AMP-lok contacts are shown by reference to the numbered points in the figure: 1)



Mating contacts are identical, utilizing a functional bow design creates a wiping action for maximum conductivity. A locking lance and a positive stop prevent retraction of the contacts from the housings. 2) Contacts are tin-plated brass, tin-plated phosphor bronze or goldplated versions where required. (3) All contacts provide insulation support, maintaining contact integrity under flexing, vibration and rough handling. 4) Wire sizes from #16 to #22 AWG are accommodated by three sizes of contacts. Serrated contact barrels are pressure-crimped for firm contact with the conductor. 5) Multiconductor housings are available in 3, 4, 6, 9, and 12-circuit configurations and are polarized to eliminate coupling errors. The standard AMP-lok housing is modified for use on printed circuit boards by the use of two mounting holes for mounting and solder dipping on the board . . . (*From new 12-page AMPin-cert Connector folder, AMP Inc., Harrisburg, Pa.*)

FOR THIS LITERATURE CIRCLE 198 ON READER-SERVICE CARD

New Rectifier "Flats" Save Space

A new line of flat, conduction-cooled selenium rectifiers in half-wave, doubler and bridge configurations which occupy as little as one-fourteenth the space required by conventional air-cooled selenium units are now available from the Radio Receptor Company, Inc., 240 Wythe Ave., Brooklyn 11, N. Y.

The new units utilize a construction that minimizes forward resistance, resulting in lower I^2R losses and consequently less heat to be conducted away. The rectifiers are hermetically sealed in a high-thermal-conductance epoxy and the flat configuration provides excellent thermal conduction to the chassis or other heat sink. This arrangement is said to provide lower operating temperatures, with less thermal interference with adjacent com-

HV PROGRAMMABLE SUPPLY

New No. 1516 regulated dc power supply is programmable over the range of 100 v to 3000 v by connecting an external programming resistor across a pair of terminals. Output voltage is determined by: $V_{out} = 100 v + .001 \times R_{prog.}$ (in ohms). Output current range is 0 to 10 ma, with a current limiting circuit included which operates at 12.5 to 15 ma.—*Carad Corporation, 3381 Junipero Serra Blvd., Palo Alto, Calif.*

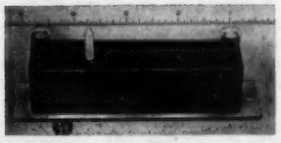
CIRCLE 199 ON READER-SERVICE CARD

GYRO TEST SUPPLY

New 400 cps, 120v 100 watt power supply is crystal-controlled to a stability of ±.0001% for precise testing of all 400 cps instruments, including gyros and stable platforms.—*Greenray Industries, Inc., 5281 E. Simpson Rd., Mechanicsburg, Pa.*

CIRCLE 469 ON READER-SERVICE CARD

BANDPASS FILTERS



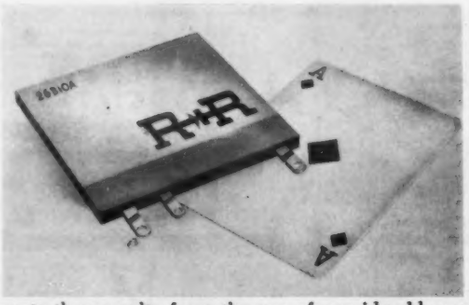
New Microwave Bandpass Filters featuring solid cast construction are supplied to any designated center frequency between 2000 and 4000 mc, with a bandpass width of from 40 to 80 mc as required.—*Electronics and Microwave Div., Instrument Systems Corp., 129-07 18th Ave., College Point 56, LI., N. Y.*

CIRCLE 200 ON READER-SERVICE CARD

MICRO SWITCHING TRANSISTORS

New triple diffused silicon planar high speed computer switches, 2N958 and 2N959 are the first EIA-registered silicon transistors in the new TO-51 micro package, .165" diameter x .060" high. They have a total switching time of less than 25 nsec and a collector to emitter saturation of less than 0.2 v.—*Pacific Semiconductors, Inc., 12955 Chadron Ave., Hawthorne, Calif.*

CIRCLE 201 ON READER-SERVICE CARD



ponents than results from the use of considerably more space by convection-cooled components.

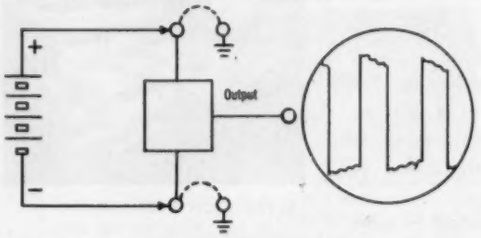
The unit illustrated is a 26 v rms input, 10 ampere dc output bridge which uses the case as one terminal. It is also available with isolated case and fourth therminal lug. Other production units up to 130 v rms input, in single and three-phase configurations are available up to 250 v-a or higher capacities. All ratings are conservatively based on case temperatures of 150°F.

FOR THIS LITERATURE CIRCLE 202 ON READER-SERVICE CARD

Tuning Fork Oscillators

Two types of transistorized oscillators having their frequency stabilized by a mechanically resonating tuning fork are self-contained signal generators; an applied dc voltage results in an ac output signal at a stable frequency.

The Custom Series (Model C) is available over a wide frequency range with frequency accuracy, output and special circuits built to the customer's exact requirements. Frequency accuracy of .002% is achieved over the range



of 50 to 30,000 cps and temperatures of 0° to 65°, or .05% over frequencies of 360 to 6000 cps and temperatures of —67° to 125°C.

The Economy Series (Model E), designed for moderate accuracy and for a limited frequency range in a fixed design at lower cost provides accuracies to 0.1% over the range of 50 to 30,000 cps over temperatures from 0° to 65°C, or 0.5% for frequencies 360 to 6000 cps over temperatures from —67°C to 125°C.

Circuitry and typical output maximum for the Model E are shown in the figure.

Model C oscillators can provide a number of outputs including: Sine wave, 3 v rms minimum into 10,000 ohm load; square wave, 8v peak-to-peak minimum to 10,000 ohm load; pulse output, in almost any waveform; and sine wave, 1 mv into 6000 ohms (.775 v rms) . . . (*From new 4-page brochure, Fork Standards, Inc., 1915 No. Harlem Ave., Chicago 35, Ill.*)

FOR THIS LITERATURE CIRCLE 203 ON READER-SERVICE CARD

RELIABLE SYSTEM DAMPING

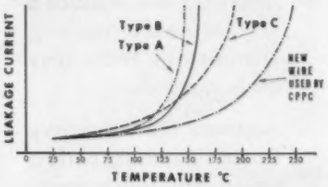
CLIFTON PRECISION MOTOR RATE TACHOMETERS

Clifton Precision QUALITY is built into this versatile line of full drag cup type Tachometers. They feature high linearity, high output to null ratios, and low inertia.

Other attractive performance characteristics are a 20:1 signal to noise ratio in standard units with ratios up to 100:1 available on special order. Power consumption is also lower than average, being 1.2 watts in typical units.

Current leakage as a variation with temperature has been significantly reduced in these units by use of a new magnet wire. See performance curves below.

Write or call for further information on these quality units to: area 215 MA 2-1000, TWX LNSDWN, PA. 1122(U) or our Representatives.



CLIFTON PRECISION PRODUCTS CO., INC.
CLIFTON HEIGHTS, PA.

cppc

CIRCLE 54 ON READER-SERVICE CARD

HI-FREQUENCY ACCELEROMETER

New Model A514TC linear accelerometer features flat response to 2100 cps in a ±100 g range made possible by Statham "gas damping." Excitation is 5 v dc or rms through carrier frequencies; output is ±20 mv at 5v.—*Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 204 ON READER-SERVICE CARD

EXTENDED RANGE BWO

New high performance backward wave oscillator provides from 10 to 20 mw power over its range of 15-22 kmc. Features are smooth curve of power output vs frequency and highly uniform, reproducible characteristics.—*Stewart Engineering Co., Santa Cruz, Calif.*

CIRCLE 205 ON READER-SERVICE CARD

GALLIUM
INDIUM
ANTIMONY
GOLD

Specifically developed to electroplate the proper concentration of alloy for the maximum in semiconductor properties.

The use of these alloys for the preparation of both "n" and "p" characteristics will produce a greater yield of working transistors than any other method.

Accurate control, heavy smooth deposits, perfect fusing, and resistance to all clean up acids and alkalis are important features of these alloys.

Information on these or any precious metal electroplating processes to meet your specifications are available upon request.

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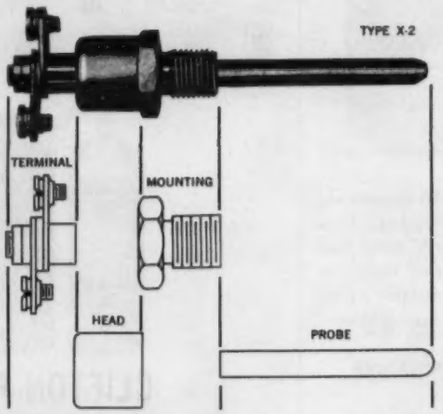
Chicago Office: 7001 No. Clark St.

CIRCLE 55 ON READER-SERVICE CARD

Thermal Switch—Rod and Tube Type



Terminations	Heads	Mountings	Probes
Wire Leads	Single Wire	Plate	¼" dia.
AN Connector	Two Wire	Thread	½" dia.
Screw Lugs	Normally Open	O Ring Groove	⅜" dia.
Solder Lugs	Normally Closed		Up to 7" length

ROD AND TUBE Thermal Switches are composed of the four basic components shown. Variations available in each component provide a multitude of units meeting a wide range of applications.

One type of thermal switch uses the rod and tube construction. This type is most highly resistant to shock and vibration while maintaining an exceptionally close differential. The differential expension of a low expanding rod within a high expanding tube acts as the thermo-responsive element, which directly makes or breaks the electrical contact.

Specifications of CPI Rod and Tube Thermal Switches are shown in tabular form for both high temperature and low temperature types:

	High Temperature	Low Temperature
Max calibration temp °F	2150	900
Min calibration temp °F	—20	—20
Allowable calibration tolerance °F	±10	±2
Safe momentary undershoot, overshoot °F	—85, 2200	—85, 1750
Voltage ac, dc	115, 28	115, 28
Current, amps resistive ac, dc	1.5	1.5
Current, amps inductive ac, dc	.25	.25
Repeatability, °F	±1	±1
Temperature differential °F	1 to 2	1 to 2
Dielectric strength, volts dc	1000	1000

Thermal switches primarily are used as warning or protective devices to signal when temperatures reach

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CIRCLE 206 ON READER-SERVICE CARD

INDUCTANCE CONTROLLED OSCILLATOR

New Model LSE inductance controlled oscillator requires only two wires from any variable inductor transducer. Tunes to any IRIG channel, V_{out} is 3 v rms, Z_{out} is 100 ohms and harmonic distortion is only 3%. Transistorized to operate on 24 to 32 v dc over the —65° to 165°F range.—*PACE Engineering Co., 13035 Saticoy St., No. Hollywood, Calif.*

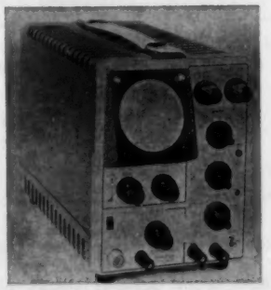
CIRCLE 207 ON READER-SERVICE CARD

FREQUENCY METER

Accurate measurement of frequencies in S, C and X bands is accomplished by new panel mounted unit which incorporates series of tunable bandpass filters. Low-pass filter eliminates spurious and tuning is by single duo-dial counter.—*Frequency Standards, P. O. Box 504, Asbury Park, N. J.*

CIRCLE 208 ON READER-SERVICE CARD

PORTABLE SCOPE



New Model 32 uses new CRT with post-deflection acceleration and 3.5 kv potential to give unusually sharp, bright trace. DC coupled amplifier has 7.5 mc bandwidth, sensitivity of 100 mv/cm and rise time of 50 nsec. Weighs only 16 lbs., for field service on computers, TV and general Lab use.—*The Scopes Company, Inc., P. O. Box 56, Monsey, N. Y.*

CIRCLE 209 ON READER-SERVICE CARD

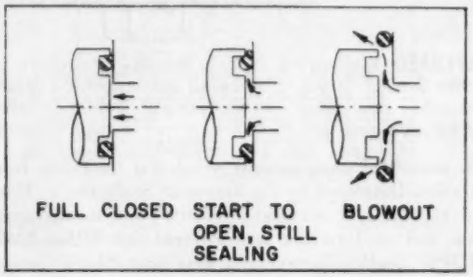
a critical level. Today these switches are used extensively in missiles, jet aircraft, gas turbines, rocket and aircraft engines airborne electronic equipment, afterburners and other high- and low-temperature applications.

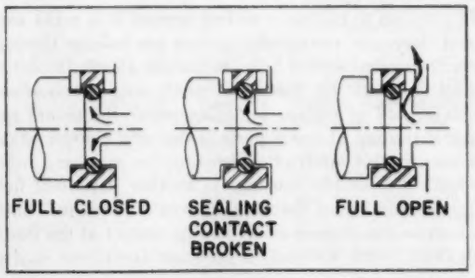
The rod-and-tube type thermal switch consists of four basic components: Terminal, head, mounting and probe (See Figure). Many materials can be used for the rod and tube, subject only to the limitations imposed by environment and the available materials and processes. The linkage itself is thermal and cannot cause adverse effects even when temperature change is gradual. Even though termed "slow-acting," thermal response is fast because the entire heat sensitive element is exposed directly to the heat source . . . (*From 4-page Rod-&-Tube Thermal Switch catalog, Control Products, Inc., 280 Ridgedale Avenue, East Hanover, N. J.*)

FOR THIS LITERATURE CIRCLE 210 ON READER-SERVICE CARD

Captive O-Ring Seal

A patented principle being applied in poppet type valves and pressure switches manufactured by the Captive Seal Corporation is shown in the two illustrations below. In the upper diagram an opening sequence for a simplified open face seal is shown. Here the pressure tends to hold

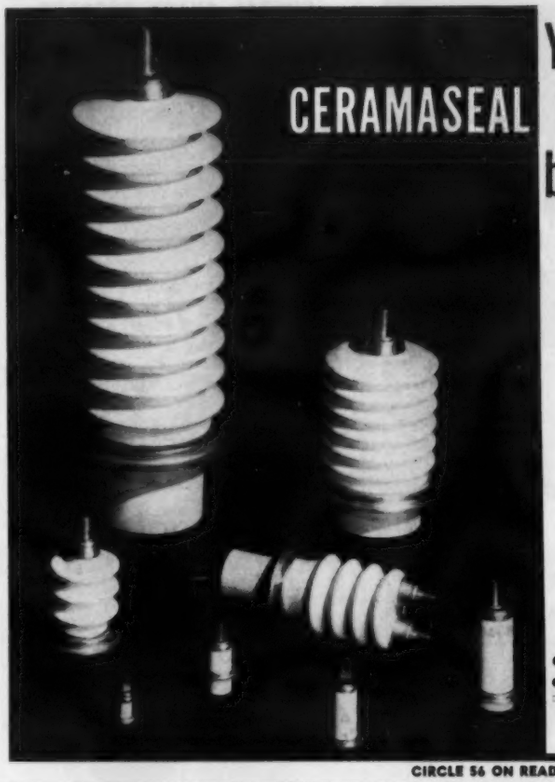




the O-ring in the opening resulting in blowout. In the lower sequence sealing contact can be broken on either side of the O-ring. This means the forces on the O-ring are balanced, keeping the ring freely in its container.

Because the Captive Seal O-ring can be made lighter and softer for easier sealing, the entire valve is said to be lighter and smaller, yet more rugged. Only a low seating force is required, making the principle particularly adaptable to solenoid operated valves and to pressure switches . . . (*From 25-page brochure CD-3, Aircraft-Missile Control Devices, Captive Seal Corporation, 121 Clinton Rd., Caldwell, N. J.*)

FOR THIS LITERATURE CIRCLE 211 ON READER-SERVICE CARD



You can safely install these HIGH-ALUMINA TERMINALS by furnace brazing

You can also operate them at 350 C in air . . . continuously. Through it all, they remain high-vacuum-tight. Such performance results from the high-temperature characteristics of the ceramic-to-metal bond.

Ceramaseal high-alumina terminals also provide:

- **Superior electrical properties**—Flashover ratings from 5.2 to 109 kv (rms), corona-start ratings of 3.3 to 33 kv (rms), in compact designs.
- **Resistance to thermal shock**—Contributes to long life for your equipment exposed to severe thermal cycling.
- **High mechanical strength**—To help reduce breakage in your assembly operations.
- **Simple installation**—You can use conventional soldering, brazing, and heli-arc welding methods.

For new 32-page high-temperature terminals and seals catalog, or other information, write Ceramaseal Incorporated, Dept. 121, New Lebanon Center, New York. Or call: West Lebanon 3-6101.

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Ceramic-to-Metal Seals, Bushings, Terminals
Sapphire-to-Metal Seals

CIRCLE 56 ON READER-SERVICE CARD

SOLID TANTALUM CAPACITORS

New line of subminiature, solid electrolyte, tantalum capacitors cover range of .0022 μf, 50v dc to 25 μf, 1.5v dc in polarized; and .001 μf, 50v to 10 μf, 2v in non-polarized ratings. Operate over ambients from —55° to 85°C without derating.—*John Hartigan, Components, Inc., Smith St., Biddeford, Me.*

CIRCLE 212 ON READER-SERVICE CARD

"FEP" WIRE IS UL APPROVED

Underwriters Laboratory approval has been granted for Teflon "FEP" wire for use in electronic data processing equipment and miniature circuits. Has rated performance at 200°C and is available in all standard colors with or without stripes, solid or stranded conductors, in gauges 20 through 26. Low dielectric capacity is coupled with high dielectric strength, mechanical toughness and non-flammability.—*Philadelphia Insulated Wire Co., Moorestown, N. J.*

CIRCLE 213 ON READER-SERVICE CARD

EPOXY ENCASED CAPACITORS

New miniature epoxy-encased metallized paper capacitors designated type GAA are available in values from .005 to 3.0 μf, and in voltage ratings of 200, 300, 400 and 600 v dc.—*Hopkins Engineering Co., 12900 Foothills Blvd., San Fernando, Calif.*

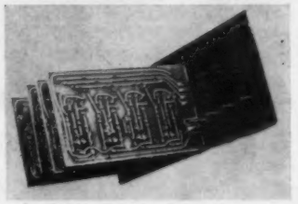
CIRCLE 214 ON READER-SERVICE CARD

HV CAPACITORS

New EF Series encapsulated high voltage capacitors in values from .005 μf through 1.0 μf and voltages from 2 kv to 30 kv without derating up to 85°C. Advance bulletin 6-TB-61 on request.—*Dearborn Electronic Labs., Inc., Orlando, Fla.*

CIRCLE 215 ON READER-SERVICE CARD

P/C BOARD CONNECTOR



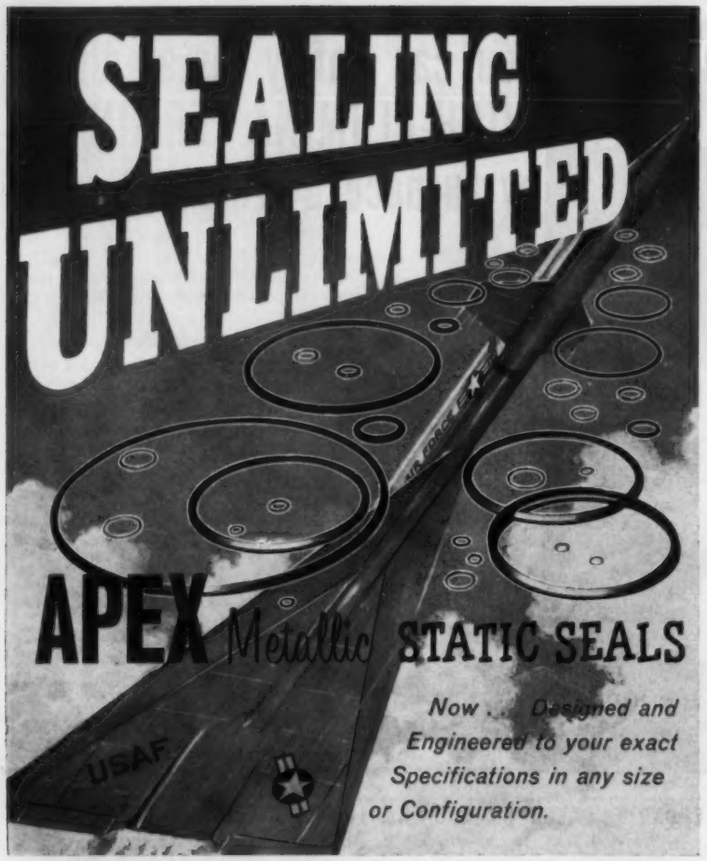
New DIGI-KLIPS® printed circuit board connector for space craft has no enclosures, can be sterilized for space or medical use, performs at temperatures over 200°C.—*Components Corp., Denville, N. J.*

CIRCLE 216 ON READER-SERVICE CARD

STRIPED SILICONE INSULATION

New process accomplishes difficult color striping of silicone rubber insulation which is permanent and eliminates colored braids which cause fraying and moisture absorption.—*Boston Insulated Wire & Cable Co., 65 Bay St., Boston 25, Mass.*

CIRCLE 217 ON READER-SERVICE CARD



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Experience proven, the APEX METALLIC SEAL is fully qualified for incorporation in all static applications and assures positive sealing in extreme environments. Rough surface finishes to 64 RMS may be sealed with very low flange loads. For further information write for catalog 1000A.

APPLICATIONS . . . Hydraulic Systems, Fasteners, Cryogenic Systems, Reactor Fluids, Servo Mechanisms, Hot Gases

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also manufacturers of... Electromagnetic Actuators (flat armature torque motors) for use in
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CIRCLE 57 ON READER-SERVICE CARD

DIGITAL SHAFT ENCODER

New Vernisyn Model VMI 15-216 provides 16-bit readout of shaft position to accuracy of ±½ bit. Output is in separate fine and coarse pulse trains accumulated on external counter. Uses magnetic, brushless pickoff requiring less than 5 watts power input, input torque 1 gm-cm, with life limited only by bearings.—*Data Tech, 238 Main St., Cambridge 42, Mass.*

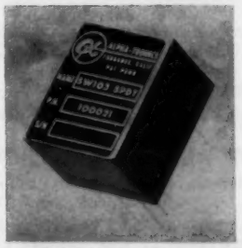
CIRCLE 218 ON READER-SERVICE CARD

MICRO CHOPPER

New Model 46 chopper of less than ½ cu-in volume has max noise level only 0.65 μv rms at 400 cps, 100-ohm load. Minimum continuous life is 2000 hrs; dwell time, phase angle and other ratings on request.—*Cambridge Div., Airpax Electronics, Cambridge, Md.*

CIRCLE 219 ON READER-SERVICE CARD

SOLID STATE CHOPPER

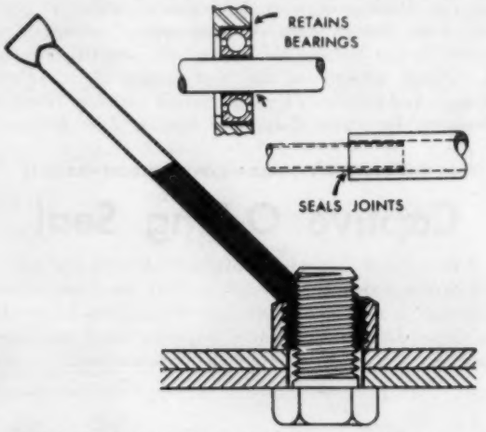


New solid state chopper SW-103 capable of operating from dc to 10 kc and requiring no external circuitry or adjustments to alternately connect and disconnect a load from a millivolt signal source has noise level below 50 μv rms at 1 kc, dwell time less than 10° at 1 kc.—*Alpha-Tronics Corp., Torrance, Calif.*

CIRCLE 220 ON READER-SERVICE CARD

New Sealant Replaces Varnish for Screw Staking

Insulating varnish, long specified by MIL-specs for securing screws in airborne electronics equipment and test equipment, has been replaced in three new specification revisions by the Aeronautical Standards Group and the Bureau of Ships by a new sealant. The new material is a penetrating resin which hardens on contact with metal to lock assembled parts against accidental loosening from vibration. Developed by the American Sealants Co., Hartford 11, Conn., it is called "Locktite" and its characteristics and performance are covered by MIL-S-22473 (SHIPS) Sealing Compounds, Retaining, Single Component, Metal Activated.



PREFERRED Method of locking threaded fasteners by Loctite Sealant Grade C is called out in MIL-P-11268D. It also has applications in the sealing of friction joints and for retaining anti-friction bearings in their housings.

In addition to its use in sealing screws, it is being used to seal electronic waveguides against gas leakage through press fits, to seal drilled holes in fibrous plastic insulators against moisture, for potting of small coils in transducer housings, and to replace soldering where the secure mechanical joining of metal parts is the only consideration. The securing of antifriction bearings in gyro and other mechanical assembly housings is another important field of application. Since the metal-activated "Locktite" hardens only in the absence of air and in contact of the liquid with clean metal surfaces, it does not contribute dust to the bearing environment.

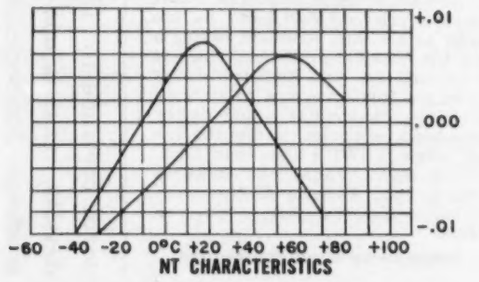
FOR THIS LITERATURE CIRCLE 221 ON READER-SERVICE CARD

Crystal Cut Characteristics

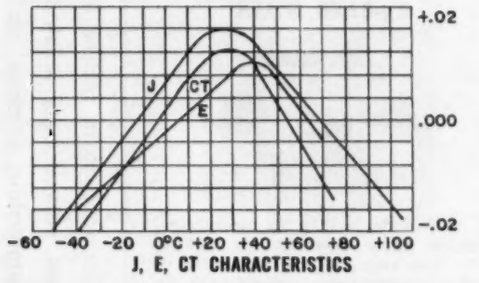
The wide range of frequencies and other characteristics available in modern crystal units is made possible by the use of properly oriented quartz plates, properly processed and excited in suitable oscillator circuits at modes which result in appropriate characteristics. The 5°X "cut," for example, when excited in the extensional mode, is known as an "E" element and is useful over the frequency range from about 60 to 200 kc; when excited in

the length-width mode ("H" element) it can be used to cover the frequency range from about 7 to 100 kc although it has been largely replaced in this range by the "N" element which gives a better temperature-frequency co-efficient. Two oppositely-poled 5° X plates cemented together and excited in the length-thickness mode ("J" element or "duplex") will produce frequencies from below 1000 cycles to about 15 kc.

The following table outlines the general characteristics of typical element types:



NT CHARACTERISTICS



J, E, CT CHARACTERISTICS

Element Designation	Usual Reference	Mode of Vibration	Characteristics
A	AT cut	Thickness shear	From .5 to 20 mc on fundamental; to 100 mc and higher on 3rd, 5th, 7th and higher overtones. Low effective resistance.
C	CT cut	Face shear	Medium values of effective resistance; 300 to 1000 kc
E	5°X cut	Extensional	Medium values of effective resistance. 60 to 200 kc
F	—18°X cut	Extensional	Medium values of effective resistance. Used mainly for filters. 60 to 300 kc.
G	GT cut	Extensional	Very good frequency-temperature characteristics, but difficult to make. Used mainly for extremely high precision standards. 100 to 200 kc. Low effective resistance.
H	5°X cut	Length-width flexure	High effective resistance. 7 to 100 kc.
J	5°X cut (2 plates)	Length thickness flexture	"Duplex." High effective resistance. From below 1000 cycles to 15 kc.
N	NT cut	Length-width flexure	High effective resistance. Better temperature - frequency characteristic than H.7 to 100 kc.

. . . (*From new 20-page catalog M62, Monitor Products Inc., 815 Fremont Ave., South Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 222 ON READER-SERVICE CARD

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NEW, COMPACT, PROGRAMMABLE, HALF-RACK, ®REGATRAN POWER SUPPLIES...

with continuously variable current limiter...

These new Regatrans are sparing only of space . . . delivering super-regulated, virtually ripple-free d-c power with the instant start-up and very high reliability of solid-state circuitry . . . and offering a group of features hitherto unprecedented in d-c power supplies of this size.

REGULATION, LINE OR LOAD, 0.1% OR 0.01 V

MODEL NUMBER	DC OUTPUT		MAX. RMS RIPPLE
	VOLTS	AMPS	
TR212A	0-100	0-100 MA	250 μv
TR018-1	0-18	0-1 AMP	150 μv
TR036-0.2	0-36	0-200 MA	150 μv

For a closer look, ask your local Electronic Measurements representative for a copy of Specification Sheet 5000 . . . or write direct.

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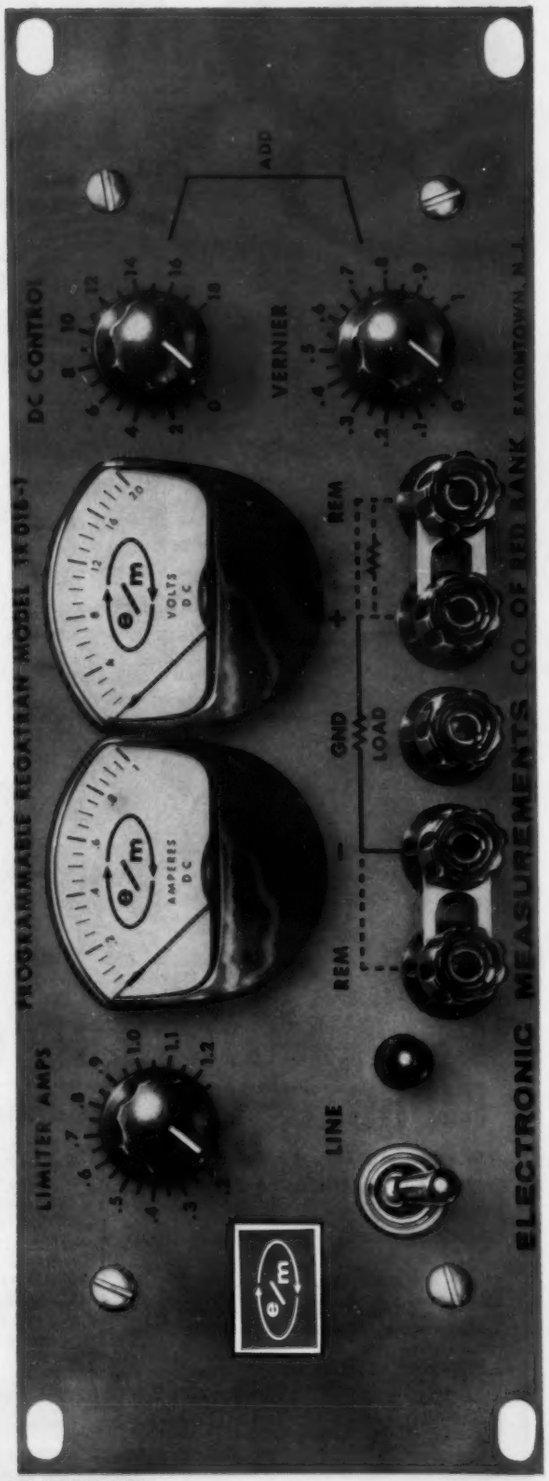
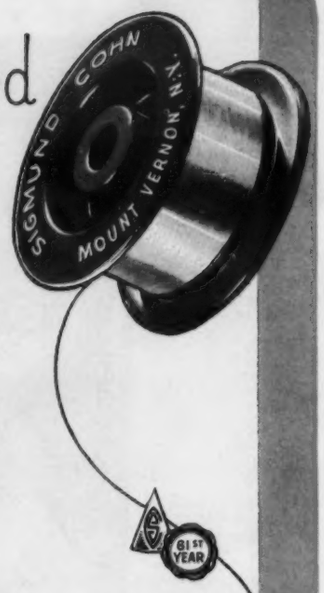


CIRCLE 58 ON READER-SERVICE CARD

Electroplated WIRES



Our processes and equipment for the continuous electroplating of wire are recognized as the most advanced in the field. All our electrodeposits are exceptionally uniform and well-bonded to the base wire . . . Gold, Silver, Nickel, Rhodium, Indium, Tin and many other metals, or combinations, can be plated onto wires of Tungsten, Molybdenum, Nickel, Bronze, Copper, Silver etc. . . . Purity of the metals, as well as the quantity deposited, are controlled within narrow limits.

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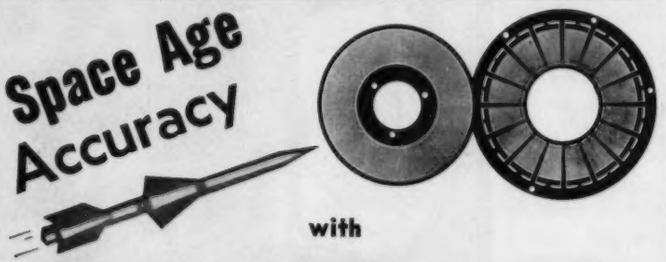

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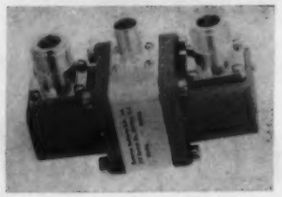
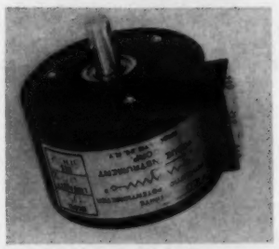
COAX SWITCH-MODULATOR-ATTENUATOR



Two new series SMA coaxial Switch/Modulator/Attenuators Model N400, at 9300mc and Model N401, at 7500 mc, capable of switching up to 7 watts microwave power, providing up to 70% modulation at frequencies from dc to 100 mc, switching time of 10 msec, and modulation input capacitance less than 10 pf.—*Somerset Radiation Laboratory, Inc.*, 192 *Central Ave., Stirling ,N. J.*

CIRCLE 223 ON READER-SERVICE CARD

WIRE WOUND POT



New single-turn, infinite resolution-wirewound potentiometer with .01% linearity features resolution of a film pot, and extremely low noise. Model #20-A is available for continuous rotation applications or with solid end stops, in resistances from ½ ohm to 1,000 ohms.—*Vogue Instrument Corp.*, 2350 *Linden Blvd., Brooklyn* 8, *N. Y.*

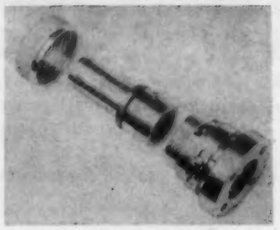
CIRCLE 224 ON READER-SERVICE CARD

WAVEGUIDE ATTENUATORS

New Shielded Variable Precision Waveguide Attenuators provide interference-free operation at low rf levels even in areas of high-level exterior fields. Model 611 (8.20 to 12.4 kmc) and Model 711 (12.4 to 18.0 kmc) give an attenuation range of 30 db with calibrations provided at five db levels at a single frequency.—*Waveline, Inc., Caldwell, N. J.*

CIRCLE 225 ON READER-SERVICE CARD

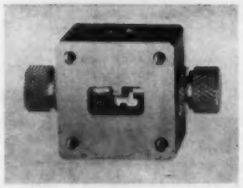
MM FEED HORNS



New 897 series of switchable linear-circular polarized feed horns for use with paraboloidal reflectors having a 0.3 f/d ratio are available for use at 3.2,4, and 8.6 mm. Radiated energy from the feed horns can be switched from linear to circular polarization by rotating a portion of the feed through 45° angle. VSWR is less than 1.3 in either mode.—*Technical Research Group, Inc., Antenna & Microwave Dept., 9 Union Square, Somerville, Mass.*

CIRCLE 226 ON READER-SERVICE CARD

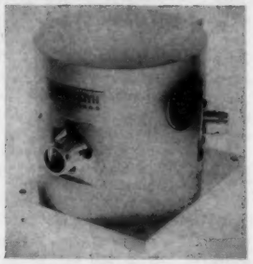
Ku-BAND MIXER



New Model V-8312 Ku band Orthomode® mixer covering the 13.3 to 13.7 kmc range uses matched pair of 1N78 crystals. Max noise figure for center band frequency is 10 db, with signal and L. O. VSWR less than 2 to 1 over a 500 mc bandwidth.—*Radiation Division, Varian Associates*, 611 *Hansen Way, Palo Alto, Calif.*

CIRCLE 227 ON READER-SERVICE CARD

FERRITE CIRCULATORS



New L-band ferrite circulator switches used as non-reciprocal SPDT switches can be switched in times down to 30 μsec. Model SL1 gives over 20 db of isolation and less than 0.5 db insertion loss over the 1250-1350 band. Model SL2 operates at 1420 mc with more than 30 db isolation and less than 0.2 db insertion loss.—*Hyletronics Corporation*, 185 *Cambridge St., Burlington, Mass.*

CIRCLE 228 ON READER-SERVICE CARD

READERS AND ADVERTISERS have much to look forward to in MSD's editorial coverage for 1962. Scheduled for special "design application" treatment are: Synchros, servos and related devices; resistors and reactive components; power supplies; microwave components; commutating devices; and solid-state components.

Orders of Logic per Clock Period

The number of logical circuits a signal can propagate through in one clock period and still properly activate the gate to a clocked device is of prime importance to EMC. Because of the nature of the semiconductor, transient times increase with temperature and vary from circuit to circuit. For this reason, it is impractical to specify transient times for every conceivable logical combination of circuits at the various temperatures in the operating range. However, since EMC does consider the point important, the following information is included to assist the equipment designer in evaluating his particular logical applications.

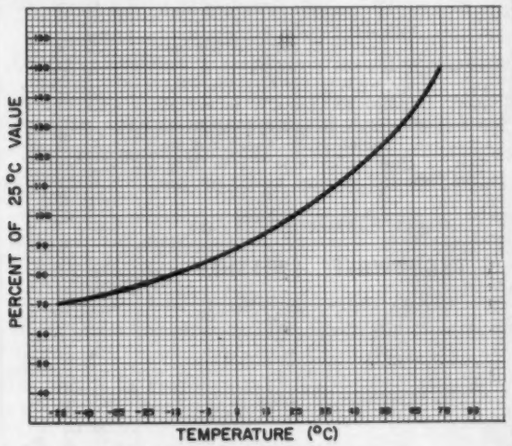


FIG. 1. PROPAGATION Time increase vs Temperature is important consideration in orders of logic which can be used in one clock period.

All four transient times will vary to some extent with the loading applied to the circuit under question and with the loading of the various circuits supplying the drive. Each circuit data sheet provides the fully loaded transient times for the respective circuit. To estimate propagation time through a logical network, all that is required is the addition of the driver stage delay and driven stage storage times (or vice versa depending on whether the final signal is a rise or fall) down the network plus the rise or fall of the last stage. To extrapolate to other than a 25°C ambient, the designer should refer to the curve of propagation time vs. temperature of Fig. 1 and multiply by the appropriate percentage. A second method would be to assemble from the first order to the last and then refer to Fig. 1. Either method will give the designer the knowledge he requires prior to actual temperature testing of the system.

As an example of what the EMC family can do and the dependence on function, at 25°C and 100 kcps a signal can propagate through 90 orders of inverter stages and properly activate a clock gate. At the other extreme, and at 71°C, and 100 kcps, 12 stages of fully loaded AND-Inverters (the slowest circuit) can be utilized . . . (*From 32-page catalog, Electronic Modules Corp., 1949 Greenspring Dr., Timonium, Md.*)

FOR THIS LITERATURE CIRCLE 229 ON READER-SERVICE CARD

5-gang assembly with precision resistor network between sections.
Super-sensitive switch assembled to be actuated at any point in electrical or mechanical rotation.
Variations of ganged assemblies with various mounts.
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Unusual, two-direction switch with spring-loaded center return.

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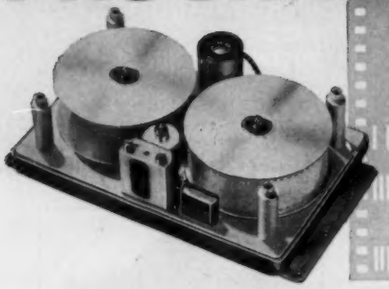

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CIRCLE 63 ON READER-SERVICE CARD

VHF BROADBAND AMPLIFIER

New low-cost broadband VHF amplifier Model LPDO1, meeting MIL-E-5400, provides 9 db gain over the entire 30-300 mc decade. Designed as plug-in module to precede a tuned

receiver it can also be used as a crystal video receiver by employing a crystal detector. Pulsing of amplifier bias line can modulate CW reception, enable RF gating, variable attenuator characteristics and AGC operation.—*Motorola Inc., Military Electronics Div., 8201 E. McDowell Rd., Scottsdale, Ariz.*

CIRCLE 230 ON READER-SERVICE CARD

DELAY LINE

New Type 6053 Magnetostriction line gives a fixed total delay of up to 16,000 μsec with fine adjustment while also providing up to 100 intermediate taps, with minimum spacing of 5 μsec, from which outputs may be taken simultaneously in any combination. Meets environmental conditions for Military ground equipment.—*Ferranti Electric Inc., Electronics Div., Industrial Park No. 1, Plainview, L. I. N. Y.*

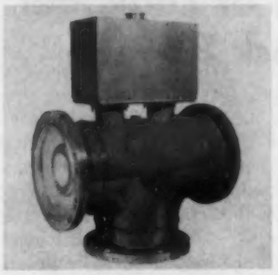
CIRCLE 231 ON READER-SERVICE CARD

DIGITAL CLOCK

New Gradinetic Digital Clock reads out time on 5 polygonal dials: one hour, one ten minute, one minute and two seconds drums. Available in 12- and 24 hour versions; 120v ac or 240v ac in 50 or 60 cps, or 115v ac in 400 cps; withstands shocks to 2000 lb/inch.—*Pennwood Numechron Co., Electronic Timing Div., 7249 Frankstown Ave., Pittsburgh 8, Pa.*

CIRCLE 232 ON READER-SERVICE CARD

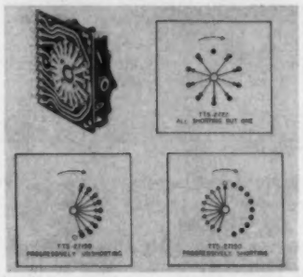
VACUUM COAX RELAY



New SPDT relay for switching high power, high frequency coaxial lines uses vacuum-enclosed contacts for low contact resistance resulting in a low and stable VSWR in any environment. Handles 300 kw CW power at 30 mc, using 24 v dc electromechanical actuation momentarily energized to open or close.—*Jennings Radio Mfg. Corp., 970 McLaughlin Ave., San Jose 8, Calif.*

CIRCLE 233 ON READER-SERVICE CARD

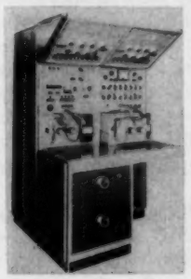
THUMBWHEEL SWITCHES



New line of 3 printed circuit thumbwheel switches designed to minimize systems space and cost are available in all-shorting-but-one, progressively shorting, and progressively unshorting styles; also lighted or unlighted.—*Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversy Blvd., Chicago 14, Ill.*

CIRCLE 234 ON READER-SERVICE CARD

TACHOMETER TEST CONSOLE



New test console for evaluating characteristics of integrating and damping tachometers over temperatures from −60° to 220°F provides temperature environment, excitation and metering to determine transformation ratio phase shift, linearity and speed characteristics.—*Instrument Div., American Electronics, Inc., 9503 West Jefferson Blvd., Culver City, Calif.*

CIRCLE 235 ON READER-SERVICE CARD

MSD's January-February 1962 issue will highlight "solid-state components" including thin films, semiconductors, diodes, zeners, rectifiers, microcircuits and related devices, and related devices, and their applications in system design. Advertisers have 'til January 10 to forward copy and plates for this important issue.

THIN-FILM MICROCIRCUITS

New "Serial Manufacturing" method using automatic control reduces costs while increasing reliability. Typical NOR circuit on 0.3" substrate containing resistors, capacitors and semiconductors is pictured.—*Rescon Electronics Corp.*, 151 *Bear Hill Rd., Waltham* 54, *Mass.*

CIRCLE 236 ON READER-SERVICE CARD

MICRO WAFER RESISTORS

New resistor elements for RCA micromodules are supplied with up to 4 resistors on .310" x .310" x .010" wafer in any combination of resistor value, termination and tolerance desired. Resistors are from 10 ohm to 100 K ohms at ⅛ watt per wafer, normally distributed at ⅛ watt per wafer.—*Microelectron, Inc.*, 1547 18*th St., Santa Monica, Calif.*

CIRCLE 237 ON READER-SERVICE CARD

1-AMP DC POWER SUPPLY

New Model AB-128R 1-ampere dc power supply unit operating input of 105-125 v, 50-60 cps with an output of 1-28 v DC, 0-1 ampere. Two meter scales 0-100 ma and 0-1 amp—show positive and negative voltages from floating output terminals. Output impedance is 0.01 ohms or less. Load regulation is ±20 mv over its full range.—*Scintollonics, Inc., P. O. Box* 701, *Fort Collins, Colo.*

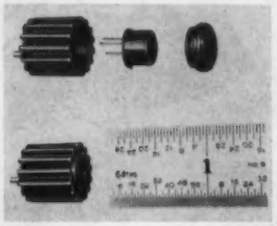
CIRCLE 238 ON READER-SERVICE CARD

MINIATURE WIREWOUNDS

New miniature wirewounds designed for high-density printed circuit applications are the T3, ¼" square, and the T4, ⅛" square. Both are ⅛" in depth, meet requirements of MIL-R-93B, and are rated ⅛ watt and ¼ watt respectively, at 125°C ambient.—*Reon Resistor Corp.*, 155 *Saw Mill River Rd., Yonkers, N. Y.*

CIRCLE 239 ON READER-SERVICE CARD

TRANSISTOR SOCKET/SINK



New miniature transistor socket and heat dissipator solders to circuit board before transistor is plugged in. Aluminum surfaces of dissipator are treated to insulate the transistor without impairing heat transfer.—*Omega Precision, Inc.*, 757 *N. Coney Ave., Azusa, Calif.*

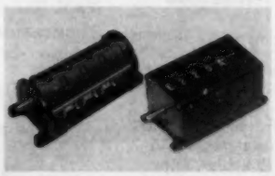
CIRCLE 240 ON READER-SERVICE CARD

THERMAL SYPHON SINK

New Thermal Syphon uses a liquid cooled sink with heat exchanger loop which is available in any length. Units are stackable to provide for high efficiency cooling of multiple transistors.—*Inland Certified Electronics*, 323 *W. Washington Blvd., Pasadena, Calif.*

CIRCLE 241 ON READER-SERVICE CARD

SPECIAL COUNTERS



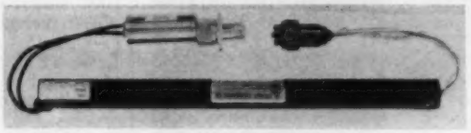
New special navigational counters indicate positional information but differ from the Kearfott standard counter line in numeral size, physical configuration and operating characteristics. Speeds up to 1800 rpm or higher, special drives, and special ranges are designed to suit customer requirements.—*Kearfott Div., General Precision, Inc.*, 1150 *McBride Ave., Little Falls, N. J.*

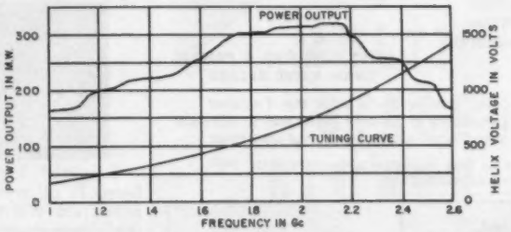
CIRCLE 242 ON READER-SERVICE CARD

For More INFORMATION on Products Listed Circle Number on Readers Service Card

Dual-Helix Backward Wave Oscillators

Stewart dual-helix (bifilar) tubes represent a major advance in backward wave oscillator design. Their power output vs frequency characteristics are more uniform, they are turnable over a greater bandwidth, and their efficiency is higher than in ordinary tube designs. The compactness of Stewart BWOs—providing the same output as from a conventional tube design of considerably greater dimensions—enables significant space economies in the equipment in which they are installed.





CHARACTERISTICS of Type OD 1-2.6 BWO Tube (pictured above) are shown in curve. Focusing field is 6.5" long, strength is 800 gauss; heater voltage is 6.3 v, anode voltage is 125 v, max.

Because of their wide-band, electronic tunability characteristics, Stewart backward wave oscillators serve as an excellent source of microwave signals for a wide variety of applications. In microwave swept signal generators, for example, they permit analysis of microwave components in minimum time. Similarly, their use is highly effective in receiving and transmitting equipment requiring rapid programmed swept signal excursions.

The tubes described here are high vacuum, hard glass and metal, helix-type backward wave oscillators. Key to their dependable, uniformly reproducible performance characteristics is their precision lens systems for forming a hollow electron beam, their accurate helix pitch and placement relative to the beam, and the care with which they are manufactured and processed.

Stewart BWOs are enclosed in protective metal capsules, with the RF output terminating either in a balanced-to-unbalanced transformer (See Figure), or a special connector, coax, and fitting assembly . . . (*From 6-page BWO Folder, Stewart Eng. Corp., Santa Cruz, Calif.*)

FOR THIS LITERATURE CIRCLE 243 ON READER-SERVICE CARD

STANDARD LINE & INTERSTAGE FILTERS

UTC STANDARDIZED FILTERS have been developed to cover the more common mid-range frequency filter requirements with stock units. All are in compact drawn hermetically sealed cases shielded to reduce hum pick-up. They are divided into seven basic types.

BMI filters are band pass interstage units designed to operate between a vacuum tube plate (or 10,000 ohms) and a grid. They provide a gain of 2 at center frequency.
BTI units are same as BMI, but 10,000 ohms output for transistor application.
BML band pass filters, similarly, work into a grid, but have an input impedance of 500/600 ohms. They provide a gain of 9.
HMI filters are high pass interstage units.
LMI filters are low pass interstage units.
HML filters are high pass with input and output impedance of 500/600 ohms.
LML filters are low pass filters with input and output impedance of 500/600 ohms.

BMI, BTI, BML, HMI, and HML special filters can be obtained for any frequency from 60 to 12,000 cycles. LMI specials are available from 140 to 12,000 cycles. LML filters are available from 500 to 12,000 cycles.

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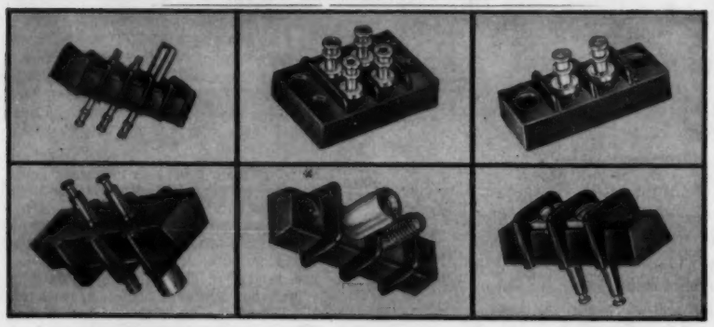

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FOR WIRING CONVENIENCE

For faster, better, and more appropriate terminations, Kulka offers all their popular terminal blocks with **your choice of terminal.** Now you can choose from regular screw-type, solder-turret, feed-through, threaded stud, or any combination of terminals to best suit your specific requirements. And, you can call your own choice of finishes — electro-tinned, silver-plated, or even gold-plated over silver. Kulka maintains complete design and consultation services to aid customers in the proper terminal selection. **Send us your requirements, or...**

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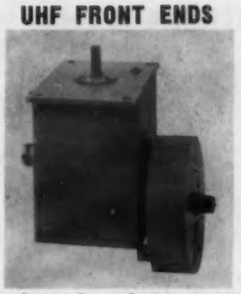
UHF FRONT ENDS



New low-noise microwave receiver front ends consist of tunable preselectors and coaxial balanced mixers with integral holders for mixer diodes. Available in L, S and C-bands, the units have a noise figure of 7.5 db max measured with a 1.5 db IF amplifier including insertion loss of the preselector.—*Frequency Engineering Labs., P. O. Box* 504, *Asbury Park, N. J.*

CIRCLE 244 ON READER-SERVICE CARD

DUAL POLARIZED HORNS

Complete line of dual polarized horns in all waveguide sizes is available from WR-430 through WR-2300 with waveguide or 1 or 2 coax inputs. Feature VSWR of less than 1.2 for 30% of the frequency band. Decoupling between inputs is greater than 30 db.—*Antenna Systems, Inc., Hingham, Mass.*

CIRCLE 245 ON READER-SERVICE CARD

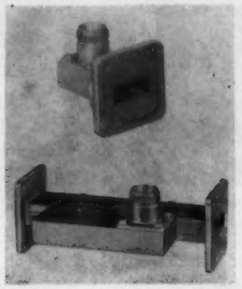
LOW-LEVEL VCO

New Type 1274A Low Level Subcarrier Oscillator, designed to operate at unlimited altitudes, is activated by a 5 millivolt level differential signal for full IRIG deviation output. It has a true differential floating input

which allows the transducer to operate at ground potential, at any dc level up to ±50 volts from ground, or it may be left floating. Consequently, it may be used in conjunction with ultra-sensitive transducers.—*Tele-Dynamics Div. of American Bosch Arma Corporation,* 5000 *Parkside Ave., Philadelphia* 31, *Pa.*

CIRCLE 246 ON READER-SERVICE CARD

MICROWAVE COMPONENTS



New line of microwave waveguide components for industrial, laboratory and educational use in standard shapes and accessories is now available through industrial distributors at approximately 50% of cost of previously available microwave equipment.—*Microwave Components, Inc. Doylestown, Pa.*

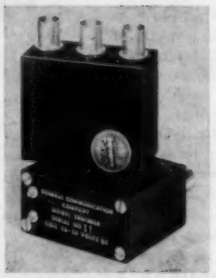
CIRCLE 247 ON READER-SERVICE CARD

LOW-LOSS RADOMES

New Taco radomes keep antenna aperture clear of snow, ice or accummulated leaves or sand under the most adverse climatic conditions. Supplied for heated, unheated, linear or dual polarized antenna designs.—*Technical Appliance Corporation, Sherburne, N. Y.*

CIRCLE 248 ON READER-SERVICE CARD

COAXIAL RELAYS



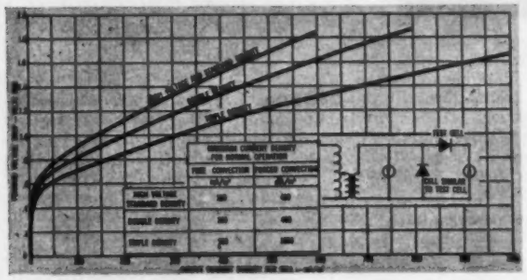
New GCC relay-type RF SPDT relay for applications to 1 kmc has crosstalk attenuation of 40 db or more and 0.25 max insertion loss. VSWR is 1.25 to 1 with 50-ohms termination. Standard connectors are Type BNC but can be supplied in Types N, TM or TNC.—*General Communication Co., 677 Beacon St., Boston* 15, *Mass.*

CIRCLE 249 ON READER-SERVICE CARD

READERS AND ADVERTISERS have much to look forward to in MSD's editorial coverage for 1962. Scheduled for special "design application" treatment are: Synchros, servos and related devices; resistors and reactive components; power supplies; microwave components; commutating; devices and solid-state components.

Compact Selenium Rectifier Modules

Advanced metallurgical and chemical processing techniques aimed at improving performance in Standard and High Voltage Selenium cells has brought forth Double Density Cells, offering twice the current-handling capabilities of standard cells; and Triple Density Cells, providing three times higher current capacities. Where cell



TYPICAL Forward Voltage Drop vs Current Density, for single phase half-wave, centertap, bridge resistive or inductive load and 3-phase half-wave circuits.

size and bulk are important design parameters, Double and Triple Density Stacks offer significant savings in space and weight over standard cells.

In designing the voltage rating of a rectifier stack, the normal line variations (± 10%) and transformer regulation (3% to 5%) must be considered. The stated voltage ratings of the cells are the maximum allowable continuous voltages that can be impressed on the cells; therefore, the voltage rating of the selenium stack must be 10% to 15% above the nominal input voltage.

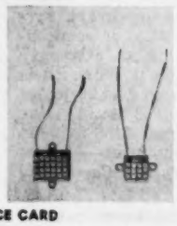
For dc blocking applications, the maximum dc voltage is 80% of the rms rating. For single-phase half wave rectifiers with capacitive or battery loads, the maximum allowable applied voltage is one-half the rms rating of the cell.

The curve above shows the dynamic rms forward voltage drop per cell as a function of rectified output current density for single phase (180° conduction) operation of Standard and High Voltage, Double Density and Triple Density cells. The maximum recommended current density under free convection or forced air cooling is shown in the inset table . . . (*From new 6-page Selenium Rectifier Stack Bulletin SR-710, International Rectifier Corp., El Segundo, Calif.*)

FOR THIS LITERATURE CIRCLE 250 ON READER-SERVICE CARD

COOLING/HEATING MODULES

New thermoelectric modules using 1/10 the amount of current normally required to heat or cool are the 2-volt Model 615 with 4.25 watts heat pumping capacity and the 4-volt Model 629 with 8.6 watts capacity. Mount in any position, withstand military environmental conditions.—*Jepson Thermoelectrics, Inc.*, 139 *Nevada St., El Segundo, Calif.*



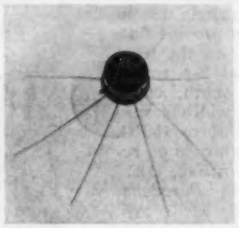
CIRCLE 251 ON READER-SERVICE CARD

COAX SOLID-STATE SWITCH

New high-speed wide-band coaxial switch gives SPDT action for power levels up to 200 mw over frequencies from 0.1 mc to 400 mc with switching speeds of 50 nsec. At 200 mc, open circuit attenuation is greater than 55 db and insertion loss less than 1 db. Weighs less than 2½" oz.— *Sanders Associates, Inc., 95 Canal St., Nashua, N. H.*

CIRCLE 252 ON READER-SERVICE CARD

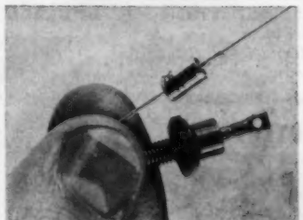
MULTIPLE LOGIC ELEMENT



New TI603 μ-mul-ti® high speed logic element combines two wafers, each consisting of one transistor and two diodes made by the planar epitaxial technique, into one TO-5 eight-lead header. The flip-flop features total saturated switching time less than 40 nsec at 10 ma. Available in sample quantities.—*Texas Instruments Inc., P. O. Box 5012, Dallas 22, Tex.*

CIRCLE 253 ON READER-SERVICE CARD

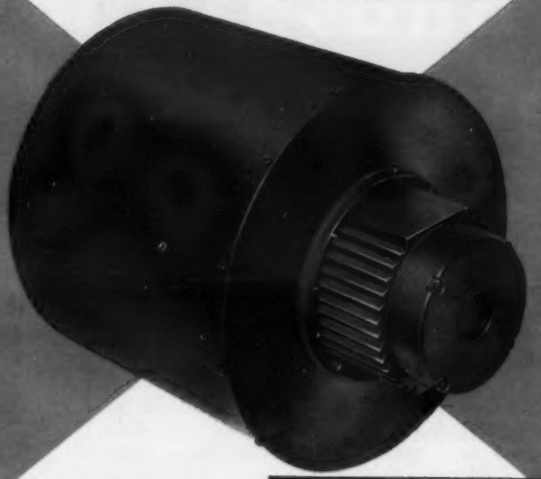
ZENER DIODES



New JEDEC Type 1N3000 Series, 1-watt Miniature silicon zener diodes require no heat sink for operation at 25°C. 10-watt stud-mounting 1N2900 Series dissipates maximum power at ambients to 55°C. Both are available in 6.8 to 200 volt ranges. Max forward voltage drop at 200 ma is 1.5v. —*Rectifier-Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.*

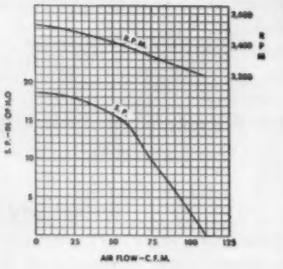
CIRCLE 254 ON READER-SERVICE CARD

the pressure's on for '61



MULTI-STAGE BLOWER

60 cps or 400 cps
1φ or 3φ
To 440 Volts
10" O.D. by lengths up to 14"
Ambient Range: —55° + 85° C
Commercial or Military



MULTISTAGE BLOWER
60 cps — 6 Stages

When engineering specifications require continuous duty and quiet long life, Air Marine offers multistage blowers for low volume, higher pressure applications to 1 psi with air delivery to 100 CFM. Featured is long life with low noise. Where high pressure is required or on such vacuum applications as tape retention, the Air-Marine multistage blowers are the efficient answer.

Our field engineers will gladly assist you in the selection and application of motors, blowers or fans.

Air Marine motors, blowers and fans have been designed and tested to meet the specifications of both the military and industry.

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CIRCLE 67 ON READER-SERVICE CARD

Isoelastic Gyro Rotor Bearings

A gyro rotor must operate at high speeds to produce the high angular momentum necessary for high gyroscopic sensitivity. The gyro must operate smoothly and maintain a constant speed and center of gravity throughout a long operating life. The requirements for gyro rotor bearings are:

Suitability for high speeds.
Close control of elastic rigidity.
Great smoothness in operation.
Cleanliness and lubrication consistent with its life.
Dimensional accuracy.
Uniform torque.

Most common among such bearings are the angular contact separable inner ring designs (Fig. 1). These provide good axial stiffness under acceleration loads due to their relatively high contact angle and ease of assembly. They are fitted with one-piece separators fabricated from suitable non-metallic material, vacuum-impregnated with instrument oil. This oil is slowly released from the separator to the working surfaces of the operating bearing. This type of lubrication prevents uncompensated error which formerly resulted from uncontrolled location of grease in gyro bearings.

Isoelasticity

Precessional error of precision inertial gyroscopes under acceleration loading may be minimized by designing for an isoelastic system. With isoelastic design, the gyro rotor will yield, under all angles of acceleration loading, in the direction of the reaction force. Thus a torque cannot be developed about the gimbal axis.

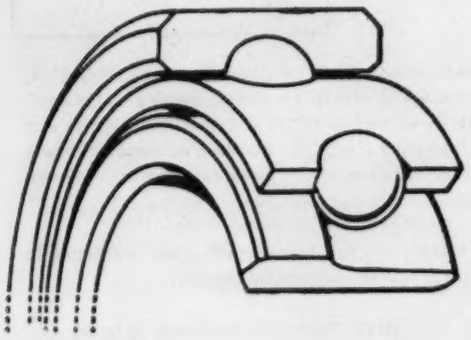


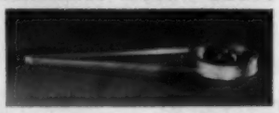
FIG. 1. NON-METALLIC SEPARATOR, for high speed (up to 100,000 rpm) applications such as gyro rotors, retains oil which is slowly released to working surfaces.

HIGH-POWER SWITCH TUBE

New Type 6544 aircooled triode is improved version of 1 megawatt shielded grid switch tube for use in radar pulse modulators or amplifiers. 10" high x 5¼" dia, other characteristics on request. —*Nuclear Corporation of America, 2 Richwood Place, Denville, N. J.*

CIRCLE 255 ON READER-SERVICE CARD

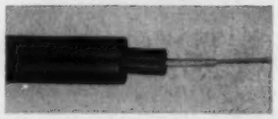
SEAMLESS MYLAR BELTS



Precision power transmission by seamless Mylar belts precisely dimensioned to customer specs provide flutter- and slip-free power in the fractional and sub-fractional h-p range. Tolerances to .015" in length, .0001" on thickness and .005" width assure high accuracy from —60° to 150°C. Sales and technical design data on request.—*Kinelogic Corporation, 1256 North Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 256 ON READER-SERVICE CARD

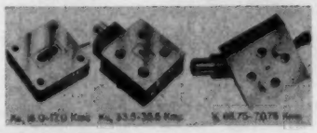
BUOYANT CABLE



New 1-conductor cable with black foamed polyethlene outer jackets over an extruded natural polyethylene inner jacket has a specific gravity of 0.76, making it buoyant in fresh water. Exterior is smooth to permit insertion of an "O"-ring seal anywhere along its length.—*Times Wire & Cable Div., The International Silver Co., Wallingford, Conn.*

CIRCLE 257 ON READER-SERVICE CARD

CRYSTAL PROTECTORS



New VHF crystal protectors featuring protection to peak powers of 10 kw, low insertion loss and short recovery times are the BSL-523, BLT-058 and BSL-513 covering bands in the 16.0 to 70.75 kmc spectrum.—All are available for immediate delivery. —*Bomac Laboratories, Salem Road, Beverly, Mass.*

CIRCLE 258 ON READER-SERVICE CARD

SOLDER/BRAZING SPHERES

Wide variety of solder and brazing alloy spheres in sizes from .0005" to .125" diameter are available for automatic production techniques. Stock samples for evaluation free to requests from responsible individuals on company letterhead.—*Semi-Alloys, Inc., 20 North MacQuesten Parkway, Mount Vernon, N. Y.*

CIRCLE 259 ON READER-SERVICE CARD

PROGRAM SWITCH

New Missile Interrogation Switch incorporating Series 1900 minature switches is available in a Series 2000 assembly with up to 96-pole, 12 position configuration. Other variations, manual or remote solenoid driven, can be readily adapted.—*Janco Corporation, 3111 Winona Ave., Burbank, Calif.*

CIRCLE 260 ON READER-SERVICE CARD

PULSED LIGHT SOURCE

New ultra-high-speed flash source for schlieren and shadowgraph systems, carrier-life testing of semiconductors, etc., requiring an extremely short pulse is available in four models with energy levels from 2 to 20 joules and durations from .3 to 1 μsec. Source diameter is from .015" to .060" depending on energy level.—*Unilectron Inc., 129 Binney St., Cambridge 42, Mass.*

CIRCLE 261 ON READER-SERVICE CARD

DUAL OUTPUT SUPPLY

Giving two 150 v, 150 ma dc outputs, both positive and negative. The Model 11403-150 power supply features 0.5% regulation and less than 15 mv peak-to-peak ripple, operating from 115 v 400 cps single-phase power. Normally furnished uncased, salt-spray, sand and dust protection provided on order.—*Reed & Reese, Inc., 717 North Lake Ave., Pasadena, Calif.*

CIRCLE 262 ON READER-SERVICE CARD

DC POWER MODULES

New DC Power Modules operating on 105-125 v, 50 to 400 cps provide regulated outputs from 2.8 to 52 volts dc at powers of 1.0 to 20 watts. Models providing 0.05% regulation with 1 mv ripple or 0.5% regulation with 5 mv rms ripple. Standard models rated to 65°C and new high temperature models with silicon transistors and tantalum capacitors for operation to 100°C are available.—*Technipower, Inc., 18 Marshall St., So. Norwalk, Conn.*

CIRCLE 263 ON READER-SERVICE CARD

SQUARE WAVE POWER

First model in new line of square wave power sources for missile checkout systems is series SQP-106T with output of 6 va with rise time less than 250 nsec and symmetry within 500 nsec. Output voltage is variable 0 to 60 v peak to peak at single fixed frequency from 50 cps to 20 kc when driven from external sine wave signal or from built-in source.—*ELIN Div., International Electronic Research Corporation, Burbank, Calif.*

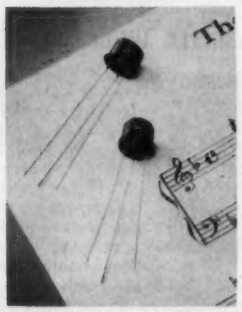
CIRCLE 264 ON READER-SERVICE CARD

DC-DC/AC CONVERTERS

High efficiency low-voltage power converters for use with solar power, fuel cell or thermoelectric generator sources utilize inputs as low as 0.1 v, convert more than 75% of input to either ac or dc. Unit shown is encapsulated Model DPC-113 for 10 watts input, weighing only 1¾ lbs.—*The Hoover Company, Electronics Div., P. O. Box* 181 *Baltimore* 3, *Md.*

CIRCLE 265 ON READER-SERVICE CARD

SILICON CONTROLLED RECTIFIER



New Series C5 all-diffused, low current SCR in a standard JEDEC TO-5 housing is usable both as a sensitive signal amplifier and a power switching element in low-power switching control circuits. The device can also be used as a high voltage PNP transistor. Average forward current is 1 amp dc; voltage breakovers range from 25 to 400 vdc. Eleven separate characteristic curves are given in new 6-page brochure 150.-10. —*Rectifier Components Dept., General Electric Co., West Genesee St., Auburn, N. Y.*

CIRCLE 266 ON READER-SERVICE CARD

HIGH VACUUM RECTIFIERS

New type 4B31 (upper) designed as clipper for improved radar scope signals, can be used as high voltage rectifier; type 8020W is hard vacuum, high voltage, half wave rectifier for use in high ambients and up to 375 G shock.—*Cetron Electronic Corp., 717 Hamilton St., Geneva, Ill.*

CIRCLE 267 ON READER-SERVICE CARD

To achieve an isoelastic system, both the bearing and non-bearing portions of the rotor may be designed for yield rate ratio of one; or the preloaded rotor pair may be designed, within certain practical limits, to compensate for unequal yield rates of the remainder of the rotor assembly.

The graph in Fig. 2 which has been generalized by use of dimensionless representation of preload—illustrates the influence of initial contact angle and preload on the yield rate ratio of any preloaded bearing pair. It is evident from the family of curves that the contact angle plays a primary role in establishing desired yield rate ratio, whereas preload has a very minor influence.

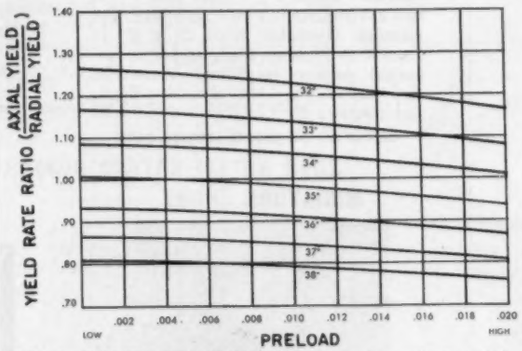


FIG. 2. CONTACT ANGLE plays a major role in establishing yield rate ratio, whereas preload has only a minor influence. O° denotes pure axial load; 90°, pure radial load.

New Departure sales engineers are qualified to handle specific design problems for preloaded bearing assemblies . . . (*From 49-page Miniature Instrument Bearing Catalog, New Departure Div., General Motors Corp.,* 269 *No. Main St., Bristol, Conn.*)

FOR THIS LITERATURE CIRCLE 268 ON READER-SERVICE CARD

FREQUENCY STANDARD

New Crystal controlled standard package at 1 megacycle or any frequency from 500 kc to 20 mc combines crystal, oscillator and amplifier circuitry in a precision controlled oven, to maintain frequency within 2 parts in 10^7.—*Greenray Industries, Inc.,* 5281 *E. Simpson Rd., Mechanicsburg, Pa.*

FOR THIS LITERATURE CIRCLE 269 ON READER-SERVICE CARD

VOLTAGE REFERENCE

New solid-state voltage reference source Type PR1, is available in modela to accept both 115 v and 6.3 v inputs, from 50 to 400 cps. Outputs may be specified at 5.9, 8.6, 11.0; 14.5, 17.2 and 22.0 volts, nominally. Isolation of output from line voltage change is approximately 100 db.—*CircuitDyne Corp.,* 480 *Mermaid St., Laguna Beach, Calif.*

FOR THIS LITERATURE CIRCLE 270 ON READER-SERVICE CARD

split second timing
in Your Aero-Space Circuits
demands
EAGLE
Mil-Spec
MOTOR DRIVEN TIMERS
"AR" SERIES RESET TIMER
Following predetermined time cycle, motor stops. When clutch is released, timer resets to starting position within 150 milliseconds.
"AP" SERIES PROGRAM TIMER
Unit repeats predetermined cycle continuously until power to the motor is interrupted.

Here's a PERFECT PAIR of miniature, hermetically sealed motor driven timers for both airborne and ground support applications. Operative in 12 G acceleration, these versatile units perform reliably in extremes of vibration and temperature.

SPECIFICATIONS

• COMPACT—2¼ x 4½" outside cylinder dimensions • LIGHT WEIGHT—30 oz. or less • UP TO 7 independent load circuits • TIME CYCLES—1 second to several hours • POWER INPUT—Choice of 115 V., 60 cycle; 115 V., 400 cycle; 28 V.D.C. • FLEXIBLE—Can be equipped with plug-in header for quick change of time cycles

Write for Bulletins 825 and 830 or call your local Eagle Representative. He's listed in Sweet's Product Design File, Section 7d, or in Thomas Register.

TIMERS ALSO CUSTOM-BUILT TO MIL-SPECS. COMPLETE FACILITIES FOR QUALIFICATION TESTING.

Plug-in Reset Timers | Precision Interval Timers | Multiple Circuit Timers | Pneumatic Timers | Heavy Duty Repeat Cycle Timers | Heavy-Duty Step Switch

MANUFACTURERS OF THE MOST COMPLETE LINE OF GROUND SUPPORT TIME CONTROLS.

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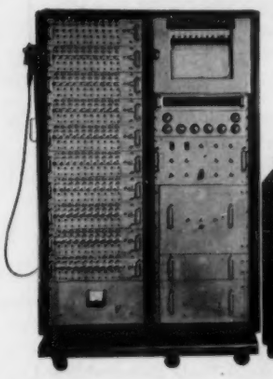
NOW
INDIVIDUALLY
CALIBRATED
FIXED
COAXIAL
ATTENUATORS
DC-4 KMC
PRECISION
RLC A21
COAXIAL
ATTENUATORS
Advanced resistor film technology insures stability, large power handling capabilities, and mechanical ruggedness. All units are individually calibrated.
Frequency Range: DC-4 Kmc
Attenuation Range: 0-60 db
Attenuation Accuracy* : ½ db (0-29 db)
¾ db (30-60 db)
VSWR: 1.25
Power Rating: 2 watt average, 2 Kw peak
Calibration Frequency: 1.2 & 2.8 Kmc
Connectors: N, TNC, BNC, C
Size: ⅜" dia. x 2¾" (0-29 db)
⅜" dia. x 4" (30-60 db)
* Absolute attenuation and variation of attenuation as a function of frequency.
0-29 db—$27.50 each from stock
30-60 db—$37.50 each from stock
Attenuators with different power ratings, frequency coverage, etc. are available on request.
R L C ELECTRONICS, INC.
25 MARTIN PLACE - PORT CHESTER, NEW YORK - WESTMORE 7-4770

CIRCLE 69 ON READER-SERVICE CARD



100 CHANNEL STRAIN GAGE SYSTEM WITH BOTH ANALOG RECORDING AND DIGITAL READOUT

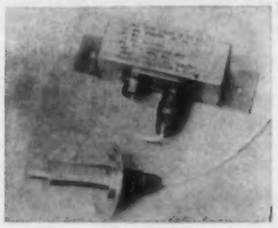
- direct strain readout on typewriter, paper tape punch, digital lamp bank and recorder simultaneously
- inherent flexibility to adapt plotter, summary punch, or other end equipments
- sophisticated system controls
- modular construction offers ability to expand both input and output of system
- designed by strain gagers for strain gagers
- B & F's answer to the problem of documenting strain information with maximum accuracy and ultimate ease.

B & F instruments, Inc.
3644 N. Lawrence St.
Philadelphia 40, Pa.

CIRCLE 70 ON READER-SERVICE CARD

FOR ADDITIONAL INFORMATION ON THE PRODUCTS LISTED, CIRCLE THE CORRESPONDING NUMBER ON THE INQUIRY CARD BOUND IN THIS BOOK AND DROP IT IN THE MAIL TODAY!

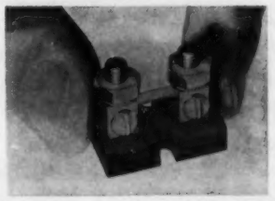
ULTRASONIC LEVEL CONTROL



New ultrasonic liquid level control uses a solid-state switch to eliminate the conventional relay. Entire system operates under high shock and vibration environments aboard silo-launched missiles. Operates from 28 v dc in from 2 to 20 msec from loaded to unloaded sensor condition.—*Acoustica Associates, Inc.*, 10400 *Aviation Blvd., Los Angeles* 45, *Calif.*

CIRCLE 271 ON READER-SERVICE CARD

MINIATURE SHUNT



New external ammeter shunt Series 8500 meeting MIL-S-61B but only half size of standard shunt features stable T/R characteristics, linear current/voltage output curve and standard accuracy to ±0.3%.—*Janco Corporation*, 3111 *Winona Ave., Burbank, Calif.*

CIRCLE 272 ON READER-SERVICE CARD

COMPONENT TEST HEATER

New Thermo-Probe Model 35 heater provides bench-top temperature testing of circuits and components from power transistors down to subminiature diodes. Probes fitting component under test are controlled at set temperature within ±3°C. Temperature stability is 0.5°C. Interchangeable probes are 35 watt and 9 watt capacity to allow choice of heater speed and capacity.—*Kennedy Company*, 2029 *North Lake Ave., Pasadena, Calif.*

CIRCLE 273 ON READER-SERVICE CARD

WIDEBAND RF TRANSFORMER

New Type 1900 transformer provides isolated coupling between 75 ohms unbalanced to 1200 ohms balanced, over a range of 200 kc to 50 mc. Insertion loss is less than 1 db and secondary balance better than 40 db. Three case styles and electrical characteristics in new bulletin 1900-1.—*North Hills Electronics, Inc., Alexander Place, Glen Cove, L. I., N. Y.*

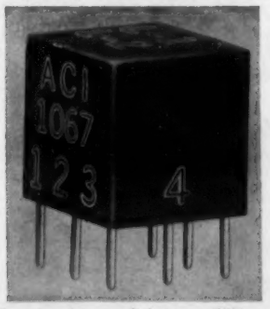
CIRCLE 274 ON READER-SERVICE CARD

VARIABLE INDUCTOR

Electrically variable inductor serving the low audio range, EL-215, is a miniaturized saturable-core reactor wound on optically matched, ultra-thin laminations of special alloy. Used to determine frequencies in audio filter and oscillator circuits and as a low-frequency sweeping device, its range is 30 to 450 cps min to 250 to 3750 cps maximum.—*Vari-L Company, Inc.*, 207 *Greenwich Ave., Stamford, Conn.*

CIRCLE 275 ON READER-SERVICE CARD

MINI RF TRANSFORMERS



New custom miniature RF magnetic components including encapsulated RF transformers for airborne modulating systems, modular RF antenna coils, and inductors for crystal filters are described in new bulletin 561.—*Applied Components, Inc.*, 401 *E. Beach Ave., Inglewood, Calif.*

CIRCLE 276 ON READER-SERVICE CARD

PEAK PULSE POWER METER

New Series 5000 pulse power calibrator uses interchangeable RF heads to cover different frequency bands. Notch-wattmeter type display matches height of unknown pulse to standard pulse, precision attenuator provides for input power levels from −5 to +63 dbm. Model 5205 RF unit covers 8.5 to 9.6 kmc.—*General Communication Co., 677 Beacon St., Boston 15, Mass.*

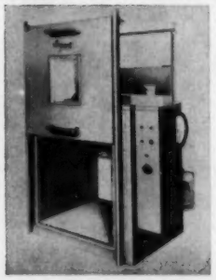
CIRCLE 277 ON READER-SERVICE CARD

DECADE ATTENUATOR

New Model DA-1 Decade Attenuator for ac or dc covers 0 to 111 db in steps of 0.1 db and consists of 3 shielded decades. Model DA-2 incorporates 2 decades, covering 0 to 110 db in steps of 1 db. Each decade comprise four resistive "T" pads having 1, 2, 3 and 4 units of attenuation which are cam-switched to obtain 10 units of attentuation.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, Essex County, N. J.*

CIRCLE 278 ON READER-SERVICE CARD

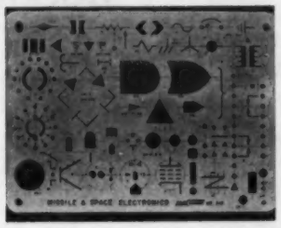
PASS-THRU OVEN



New mechanically convected pass-through oven Model 1408-M uses 550 cfm blower to ensure rapid heat transfer and uniform temperatures in 32" x 25" x 30" chamber. Heating elements operate at black heat for safety, 4" insulation prevents waste of heat.—*The Electric Hotpack Co., Inc., Cottman Ave. at Melrose St., Philadelphia 35, Pa.*

CIRCLE 279 ON READER-SERVICE CARD

MISSILE/SPACE TEMPLATE



New No. 316 Missile and Space Electronics template with symbols conforming to MIL-STD 70327 is designed for precision drawing of circuits used in guidance and control of Miliary hardware in space.—*Rapidesign, Inc., P. O. Box 429, Burbank, Calif.*

CIRCLE 280 ON READER-SERVICE CARD

BRONZE COATED PISTON RODS

New BRONZE-CASE rods used in hardened steel bushings give over ten times the life of conventional steel rods in bronze bushings. Bronze case rods are rustproof and nickproof and are available in standard diameters of ¾", 1", 1¼", 1½", 1¾", 2" 2½" and 3". Other diameters on special order. —*Thomson Industries, Inc., 1029 Plandome Rd., Manhasset, N. Y.*

CIRCLE 281 ON READER-SERVICE CARD

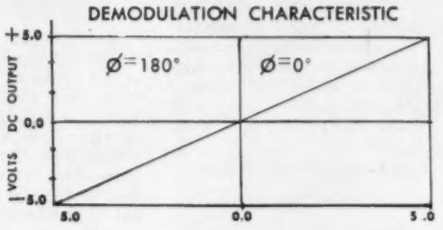
LABORATORY BREADBOARD

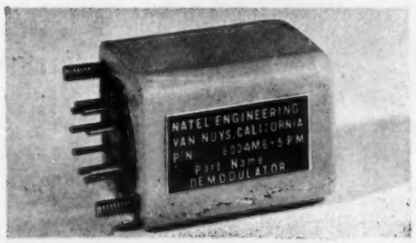
Ingeneous Model CSL Circuit Builder breadboard for design engineer and lab use has 108 gold-plated cells spaced 1" apart in rows of 12. Elastic rubber core in each cell shrinks when pulled to allow insertion of leads from resistors, capacitors, transistors, etc., which make firm contact when core is released.—*Circuit Structures Lab., P.O. Box 36, Laguna Beach, Calif.*

CIRCLE 282 ON READER-SERVICE CARD

Miniature Telemetry Demodulator

Natel Modulator/Demodulators are solid state devices packaged in hermetically sealed potted units. Modulators convert low-level dc signals to ac signals with phase and amplitude proportional to the polarity and amplitude of the dc input signal. Demodulators convert suppressed-carrier input signal to dc output signal with amplitude and polarity proportional to phase sense and amplitude of ac input signal.





DEMODULATOR for telemetry applications for signals from 200 to 50,000 cps, provides 5v dc output signal from 5v input signal. Demodulation characteristic is shown.

The Model D 6004 demodulator is a high-efficiency phase-sensitive device containing integral and reference transformers. Used as a demodulator, its output is a filtered full-wave rectified signal.

The Model D6004 can also be used as a modulator, the carrier signal being applied across the reference terminals and the signal to be modulated across the terminals normally used as outputs. The modulated output is obtained from the normal input terminals . . . (*From new set of six Product Data Sheets, Natel Engineering Co., Inc., 15922 Strathern St., Van Nuys, Calif.*)

FOR THIS LITERATURE CIRCLE 283 ON READER-SERVICE CARD

TUNNEL DIODE

Gallium Antimonide tunnel diodes Types MS 232-3-4 operate over temperatures from −55°C to 100°C with low noise and high frequency properties. Cutoff frequencies in the 2 to 4 kmc range, and peak-to-valley ratios of 16:1 and 20:1 are typical.—*Micro State Electronics Corp., 152 Floral Ave., Murray Hill, N. J.*

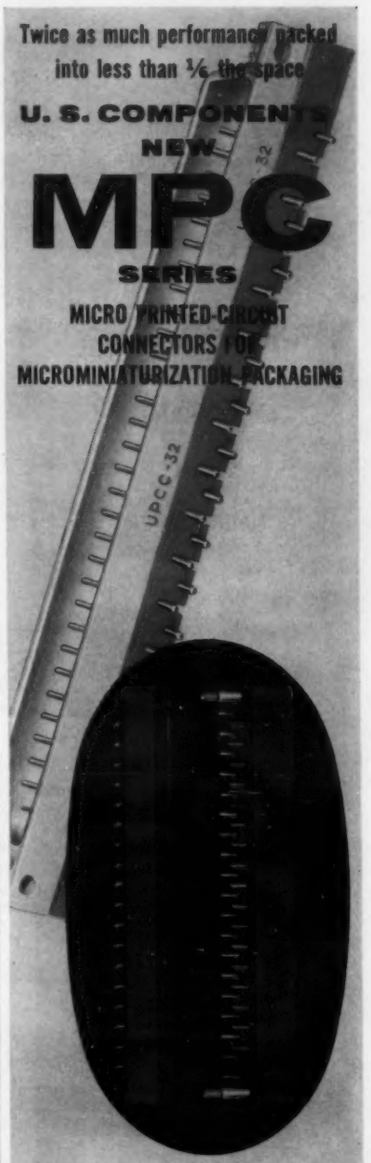
CIRCLE 284 ON READER-SERVICE CARD

Twice as much performance packed into less than ⅙ the space

U. S. COMPONENTS' NEW

MPC SERIES

MICRO PRINTED-CIRCUIT CONNECTORS FOR MICROMINIATURIZATION PACKAGING



This new two unit printed circuit connector provides proven quality performance in the "smallest" package available today. ⅙th the size of previously available connectors it assures reliability even under unusual mechanical, electrical and environmental stresses.

Comparative size of the MPC-37 contact connector is shown against the NAS TYPE 32 contact connector.

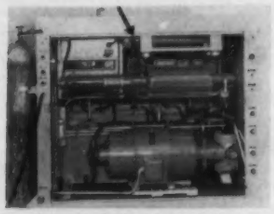
Body material is glass reinforced diallyl phthalate per MIL-M-19833, Type GDI-30 Spec. Other materials upon request.

U. S. COMPONENTS INC.

1320 Zerega Ave. • New York 62, N.Y.

CIRCLE 71 ON READER-SERVICE CARD

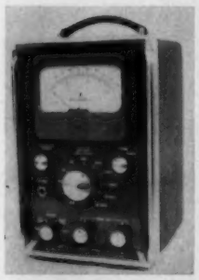
NITROGEN DRYER



New Boeing Missile Test Stand uses Hankison Dehydrafilter (see arrow) to maintain dewpoints as low as −60° to −70°F. When indicator on cartridge turns pink, cartridge can be replaced. Dry nitrogen prevents freezing of oil or moisture in missile control lines.—*Hankison Corp., Canonsburg, Pa.*

CIRCLE 285 ON READER-SERVICE CARD

GAUSSMETER



New transistorized Model 900 Gaussmeter covers range of flux densities from 0.3 gauss to 30,000 gauss with accuracy of ± 2.5% repeatability of 0.5%. Uses indium arsenide or bismuth element probes; operates from ac supply or self-contained batteries.—*Dyna-Empire, Inc., 1075 Stewart Ave., Garden City, N. J.*

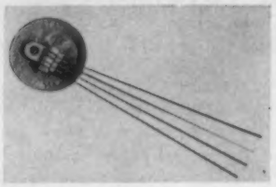
CIRCLE 286 ON READER-SERVICE CARD

LOW GRADIENT TEST CHAMBER

New Model 1060B large volume, low gradient environmental chamber for MIL-Spec testing of large-volume assemblies where temperature variation throughout the specimen cannot exceed ±1°C. Temperature range is −100° to 500°F with fast cool-down (bottled CO_2) and automatic temperature cycling.—*Delta Design, Inc., 3163 Adams Ave., San Diego 16, Calif.*

CIRCLE 287 ON READER-SERVICE CARD

INSTRUMENT RECTIFIER



Series 80 instrument rectifiers designed for use with meters of 20 μa to 200 μa full scale current features high rectifying efficiency at small load currents and improved frequency response due to active cell area of only .0012 square inch.—*Conant Laboratories, Box 3997, Bethany Station, Lincoln 5, Nebr.*

CIRCLE 288 ON READER-SERVICE CARD

HI-TEMP POWER SUPPLIES

New Series L high temperature power supplies provide optimum space utilization, power consumption and electrical characteristics over ambients from −55° to 125°C. Silicon transistors and rectifiers, tantalytic capacitors or discs and high temperature resistors and transformers are used throughout.—*Orion Electronic Corp., 108 Columbus Ave., Tuckahoe, N. Y.*

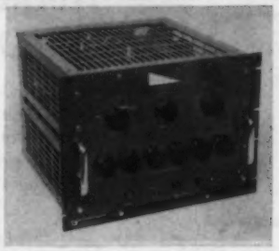
CIRCLE 289 ON READER-SERVICE CARD

RADAR PULSE NETWORKS

New Pulse compression networks, used at receiver of enhanced radar system, compress echoes in time, making it possible to distinguish long-duration pulses which partially overlap, of range resolution. Impedances from 50 to 1000 ohms can be supplied, deresulting in more range without loss pending on center frequency, bandwidth, and compression ratio.—*Ortho Filter Corp., a subsidiary of Ortho Industries, Inc., 7 Paterson St., Paterson 1, N. J.*

CIRCLE 290 ON READER-SERVICE CARD

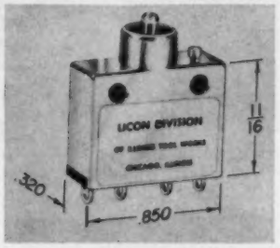
PRECISION CURRENT SOURCE



New CS-141 Ultra-Precision ac or dc current source for precision testing of all types of current sensitive devices such as transducers, resistors, gyros, semiconductors and magnetic components holds output current within .01% of full scale per day (dc) from 0 to 100 v. On ac, output current is directly proportional to external reference, permitting pulse torque operation of gyros. Full scale ranges are .1 ma, 1 ma, 10 ma, 100 ma and 1 amp.—*North Hills Electronics, Inc., Alexander Place, Glen Cove, N. Y.*

CIRCLE 291 ON READER-SERVICE CARD

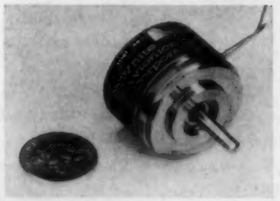
SEALED SUBMIN SWITCH



New Type 65 LICON® subminiature snap-action switches meeting immersion test requirements of MIL-E-5272 are rated at 10 amp 30 vdc/120 vac. "O" ring plunger seal plus epoxy terminal potting insure reliability in any atmosphere, at any altitude.—*Licon Div., Illinois Tool Works, Inc., 6615 West Irving Park Rd., Chicago 34, Ill.*

CIRCLE 292 ON READER-SERVICE CARD

SPDT PHOTO SWITCH



New solid-state rotary switch consisting of slotted disc passing a light beam to photo-sensitive diodes and designed for military environments up to 100°C temperatures, provide output of 150 ma at 28v dc to operate SCR's or to program computer systems.—*Scott Fauteck, White Avionics, Terminal Drive., Plainview, N. Y.*

CIRCLE 293 ON READER-SERVICE CARD

Backlash in Differentials

Backlash, with respect to differentials, is frequently a combination of true backlash and lost motion. True backlash is that amount by which the tooth space exceeds the thickness of an engaging tooth at the pitch circle and can

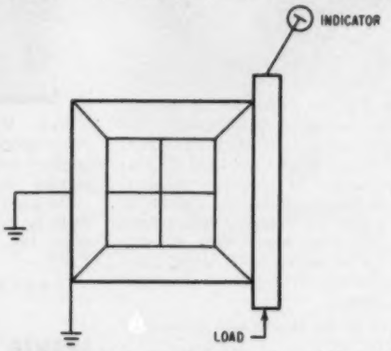


FIG. 1. SCHEMATIC DIAGRAM of a differential test set-up for determining lost motion. The end gear should be locked in such fashion as to prevent cocking—using a wedge for this purpose will remove a large percentage of the lost motion and result in a fallacious reading.

be measured only at no load.

Lost motion is composed of true backlash and a variety of other factors, some of which are:

a. Axial and radial play in the bearings.
b. Torsional wind-up of shafts.
c. Bending or deflection of gear teeth.
d. General strain in the system.

Lost motion, unlike true backlash, is a function of load and is usually measured by locking one end gear and the spider, or spider shaft, then applying a torque load on the other end gear. Measurements of lost motion are made at the pitch line of the free end gear (Fig. 1).

This requirement, or accuracy rating, is usually given in minutes of arc and indicates that at the stated loading, when tested as above, the free end gear may not rotate in excess of the lost motion specified. Since lost motion increases with the load applied, it is essential that the testing load be given (Fig. 2).

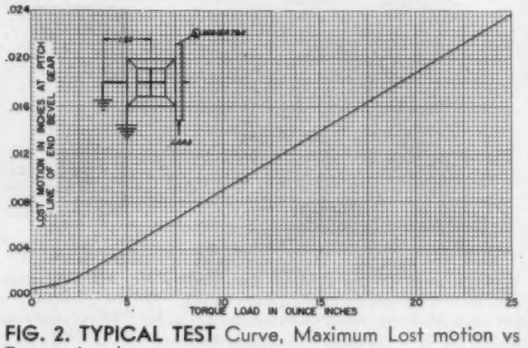


FIG. 2. TYPICAL TEST Curve, Maximum Lost motion vs Torque Load.

In order to obtain a minimum of lost motion in a bevel gear differential, certain critical design factors must be observed:

a. Bevel gears must be fabricated to extreme accuracy

(Backlash continued)

with respect to both the teeth and blanking dimensions.

b. Ball bearings of maximum precision, ABEC 5 or 7, must be used to eliminate additional runout from this source. They must then be mounted with the utmost care so as to reduce axial and radial play to the absolute minimum. This cannot be overemphasized if backlash must be kept to a minimum.

c. The spider and spider shaft must be designed and fabricated in such manner as to eliminate, if possible, any contributory errors.

d. The assembly of the differential should be accomplished only by experienced personnel. No matter how precise the various detail parts, a satisfactory end product is impossible with improper or inept assembly techniques . . . *(From new 42-page brochure, No. 8101, Precision Mechanical Differentials, Dynamic Gear Company, Inc., 175 Dixon Ave., Amityville, L.I., N. Y.)*

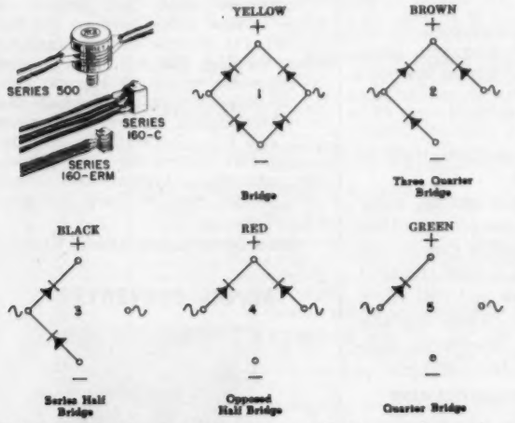
FOR THIS LITERATURE CIRCLE 294 ON READER-SERVICE CARD

Color Code Identifies Instrument Rectifier Circuit

The body color of any Conant Instrument Rectifier readily identifies its internal circuit:

Yellow—full wave bridge, 4 section
Brown—three-quarter bridge, 3 section
Black—series half bridge, 2 section
Red—opposed half bridge, 2 section
Green—quarter bridge, 1 section

Dots found on the body section indicate in accordance



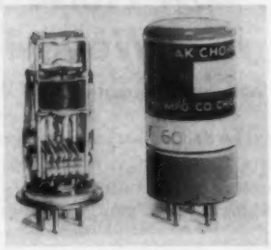
THREE SERIES of instrument rectifiers are shown (approximately half size) with internal connection schematics for each body color.

with the standard RMA color code, the number of cells in multiple cell sections; thus a green dot identifies a five-cell section, a yellow dot a four-cell section.

Terminal polarity is indicated by a color dot on the terminal, or colored wire lead insulation, as follows: Positive output is red, negative output is black, ac inputs are yellow . . . *(From 4-page Specification folder, Conant Laboratories, Box 3997, Bethany Station, Lincoln 5, Nebr.)*

FOR THIS LITERATURE CIRCLE 295 ON READER-SERVICE CARD

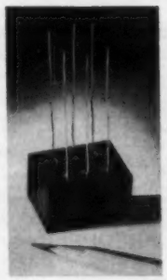
MINIATURE CHOPPER



Improved miniature 60 cps chopper designed for operational dc amplifiers in computer applications minimizes audible noise and chassis vibration; uses extra heavy shielding to reduce magnetic pickup. Nominal frequency is 60 ±5 cps at 6.3 v.—*Oak Mfg. Co., Crystal Lake, Ill.*

CIRCLE 296 ON READER-SERVICE CARD

TRANSISTOR-CHOPPER



New miniature transistor chopper Type 6022-3, for printed circuit applications incorporates drive transformer. Weak dc signals telemetered from space can be converted to pulses, amplified for readout. Full encapsulation shields chopper from shock acceleration and vibration, drive frequency is from 50 to 5000 cps.—*Cambridge Div., of Airpax Electronics, Inc., Cambridge, Md.*

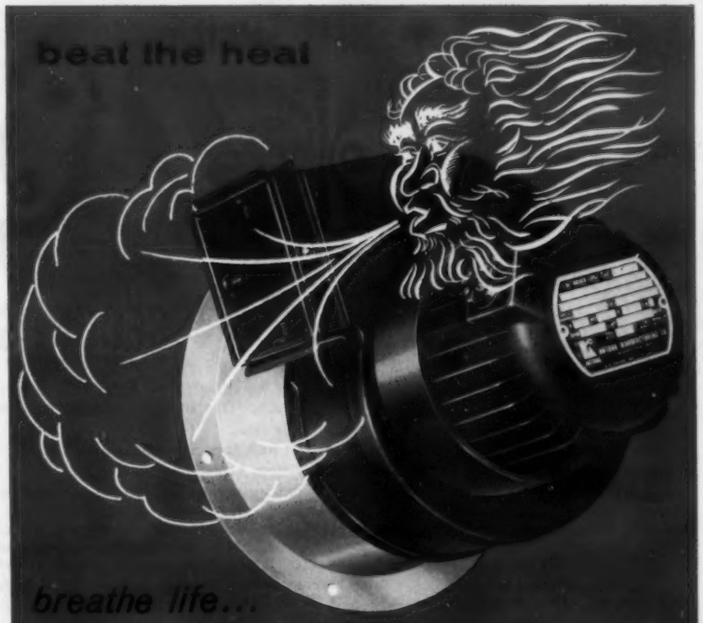
CIRCLE 297 ON READER-SERVICE CARD

MINIATURE INSTRUMENT PREAMP

New three-stage preamplifier gives amplification of 100 ±2% with frequency response from 1 cps to 1 mc, 3 db bandwidth. Maximum unclipped output at 1 kc is 8 v peak-to-peak into 100 ohms. Input impedance is 100 K. Drain on enclosed 15-v Eveready No. 504 battery is 1.2 ma.—*Ad-Yu Electronics Lab., 249-259 Terhune Ave., Passiac, N. J.*

CIRCLE 298 ON READER-SERVICE CARD

For More INFORMATION on Products Listed Circle Number on Readers Service Card



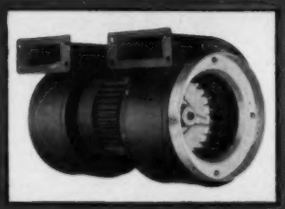
breathe life...
dependability and performance with

ROTRON MODEL D BLOWERS

For cooling these tightly packed electronic components use Rotron Model D Blowers—specifically designed to work against high airflow impedance. Offered in a wide range of sizes, styles and motor types. Motors totally sealed and have double shielded precision ball bearings.

- CAPACITY—10-720 CFM.
- Simplex or Duplex models in wheel sizes from 1½" to 7".
- 50-60 cps, 400 cps, 1 or 3 phase.
- Altivar motors for automatic air density compensation.
- Choice of rotation, outlet blast direction, inlet or outlet adaptors, mountings, and insulation Class A, F or H.
- Inverted types in wheel sizes from 4" to 7".
- Completely maintenance-free.

INSTALL THEM, FORGET THEM.



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CIRCLE 72 ON READER-SERVICE CARD

PRESTO-SPLICE DIGITAL TAPE IN 1/2 SECONDS

No Adhesives — No Drying Time Required
Perfect Tape Alignment Assured Every Time

- **Collect short-ends of information on large reel for single run.**
- **Insert corrections without re-editing — add or subtract from tape as needed.**
- **Fused splice works with both mechanical and photo-electric readers.**

Now splice all 5 to 8 channel paper tapes IN TWO SECONDS with the miracle Presto-Splicer. A few minutes work can correlate an entire day's programming.

Permanent butt-weld or overlap splice lasts under all use conditions because the splice is actually electrically fused! After splicing, tape maintains original condition — data is neither destroyed nor distorted . . . with the new information accurately inserted . . . at a tremendous cost saving in tape.

Presto-Splicers are made to meet any size or custom requirement for magnetic tape, digital paper, 35MM film, etc. Find out how — find out why! Send for our brochure.

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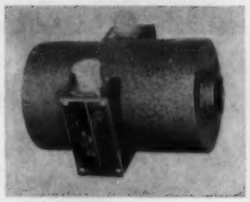
Cable: Prestoseal, New York

CIRCLE 73 ON READER-SERVICE CARD

LOAD TEST CELL



New Model 344 Alinco Universal force transducer for tension and/or compression guarantees accuracy of ±0.1% and is available in ranges from 50 to 1,000,000 lbs.—*Allegany Instrument Co., Div. of Textron Electronics, Inc.*, 1091 *Wills Mountain, Cumberland, Md.*

CIRCLE 299 ON READER-SERVICE CARD

TIME METER

New "Big Look" Type 236 elapsed time meter in 2½" and 3½" models measures up to 99999.9 minutes or hours, sealed models operate from 120 up to 480 v at 50 or 60 cps frequencies. Meet inspection, vibration, watertightness and shock of specification MIL-M-6A.—*General Electric Co., Schenectady 5, N. Y.*

CIRCLE 300 ON READER-SERVICE CARD

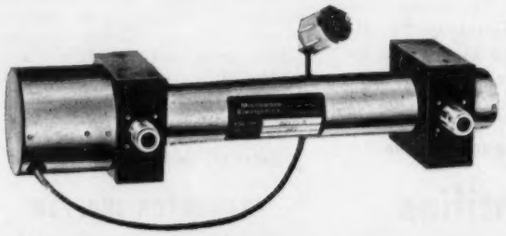
VIBRATION ISOLATOR

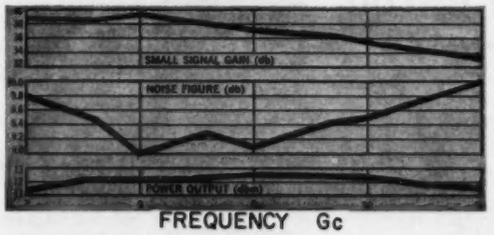
New Rocket Sled Slipper Model K1767 for vibration isolation of rocket test sleds utilizes MET-L-FLEX a cushioning material fabricated from knitted stainless steel wire. Further information on request.—*Robinson Vibrashock Div., Robinson Technical Products, Inc., Teterboro Air Terminal, Teterboro, N. J.*

CIRCLE 301 ON READER-SERVICE CARD

Low Noise Traveling Wave Tubes

Low-noise, low-power MEC Model 2105K PPM focused traveling wave tube designed for operation in the 7.0 to 11.0 Gc range, features metal-ceramic construction with a helix rigidly supported by ceramic rods over its entire length. Critical turn spacing is accurately maintained to assure uniform gain characteristics from tube to tube.





PERFORMANCE Characteristics for Small-signal Gain, Noise Figure and Power Output over its frequency range of 7-11 Gc are shown for Model 2105K, typical low-noise TWT (pictured above).

MEC tubes can be operated in any position with no degradation in perfomance.

As seen in the associated performance graphs, maximum noise figure is well below 10 db over most of the frequency range. Temperature compensation can be provided to meet the requirements of MIL-E-5400, Class 2. The tubes have been tested at 20 G shock and 15G vibration from 5 to 2000 cps with no performance degradation . . . (*From 8-page TWT Catalog, Microwave Electronics Corp.*, 4061 *Transport St., Palo Alto, Calif.*)

FOR THIS LITERATURE CIRCLE 302 ON READER-SERVICE CARD

P-C TRIMMING CAPACITOR

New miniature ceramic trimmer capacitor Style 538-007 measuring only ⅜" diameter, is now available with printed circuit terminals. Horizontally adjustable when mounted, it is available in NPO temperature coefficient ranges of 2-8 pf and 5.5-18 pf as well as N300, N500, and N650 temperature coefficients. Meets MIL-C-81.—*Erie Resistor Corporation*, 644 *West 12th St., Erie, Pa.*

CIRCLE 303 ON READER-SERVICE CARD

SUBMIN SCR

Miniaturization with no sacrifice in sensitivity, cutoff characeristics, or inherent reliability is said achieved in a new subminiature Silicon Controlled Rectifier with 2 ma triggering, dc ratings to 200 volts and 350 ma, with pulse capability to 10-amp. The new unit is available in both conventional outline and a new in-line configuration for welded modules and printed circuits.—*Solid State Products, Inc., One Pingree St., Salem, Mass.*

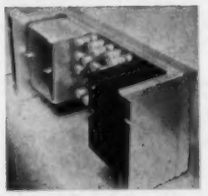
CIRCLE 304 ON READER-SERVICE CARD

ETCHED FOIL HEATERS

Resistance alloy foil etched to shape is now being used in flexible industrial electric heater blankets. After etching, the foil is laminated in Neoprene, epoxy or silicone rubber to make a thin, waterproof and extremely rugged blanket that meets MIL and UL specifications. Standby temperature control for solid propellant missiles is typical use.—*Thermal Circuits, Inc.*, 59 *Park St., Beverly, Mass.*

CIRCLE 305 ON READER-SERVICE CARD

AN/DIG CONVERTER



New general purpose Capcoder, Model OC-2000, is a high-speed capacitive charge transfer A/D converter providing a wide choice of operating speeds, data format and characteristics for voice encoding and decoding, radar data encoding for computer entry, and for general purpose use.—*Towson Laboratories, Inc.*, 200 *E. Joppa Rd., Baltimore 4, Md.*

CIRCLE 306 ON READER-SERVICE CARD

MSD's January-February 1962 issue will highlight "solid-state components" including thin films, semiconductors, diodes, zeners, rectifiers, microcircuits and related devices, and their applications in system design. Advertisers have 'til January 10 to forward copy and plates for this important issue.

MSD new literature

INTEGRATING ACCELEROMETER, operational and mathematical analyses for pendulous system composed of modified dc motor and null-sensing circuit are given in new 14-page brochure.—Integrated Dynamics Div., Globe Industries, Inc., 711 San Mateo Blvd., S.E., Albuquerque, N. Mex.

CIRCLE 307 ON READER-SERVICE CARD

FLIGHT COMMAND Instrument System giving independent navigational reference is described in 2-page data sheet 115-15.—Lear Inst. Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

CIRCLE 308 ON READER-SERVICE CARD

GYRO, Floated Rate Integrating Series 108, is described in new 2-page data sheet 116-12.—Lear Instrument Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

CIRCLE 309 ON READER-SERVICE CARD

VISCOUS DAMPED SERVO MOTOR, Size 11, is described in 2-page data sheet R180-001.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

CIRCLE 310 ON READER-SERVICE CARD

BRUSHLESS SYNCHROS and other servo components are described in new 4-page sheetform catalog 103.—Servo Controls Inc., West Chester, Pa.

CIRCLE 311 ON READER-SERVICE CARD

SYNCHROS in differential transmitters, receiver, control transformer and transmitter types are described in 2-page bulletin ST 61-2.—Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N. Y.

CIRCLE 312 ON READER-SERVICE CARD

SYNCHRO & RESOLVER Bridges for rapid quality control testing of synchro components per MIL-S-2078H and SAE, ARP-461A are described in 4-page tech bulletin.—Theta Inst. Corp., 520 Victor St., Saddle Brook, N. J.

CIRCLE 313 ON READER-SERVICE CARD

HOT GAS Servo Systems for missile, drone, and space vehicle flight control, including flicker, single-stage proportional or pulse modulating and two-stage proportional servos are discussed in 12-page bulletin LMEDJ 2817.—General Electric Co., Light Military Electronics Dept., 600 Main St., Johnson City, N. Y.

CIRCLE 314 ON READER-SERVICE CARD

ALTITUDE COMPUTER containing all electronic and mechanical equipment for measuring air pressure, converting it to pressure altitude, and providing encoder and numeric readouts and servoed outputs functions required by other high-performance aircraft systems is described in 4-page bulletin.—Guidance and Control Systems Div. Litton Systems, Woodland Hills, Calif.

CIRCLE 315 ON READER-SERVICE CARD

CONTROL SYNCHROS size 23, for 400 cycle operation, meeting MIL-Specs are described in 2-page bulletin CS-4-23-2.—Vernitron Corp., 125 Old Country Rd., Carle Place, L.I., N. Y.

CIRCLE 316 ON READER-SERVICE CARD

PRESSURE TRANSDUCER, Teleflight Model 185 a miniature instrument designed primarily for airborne applications, sensing fluid and gas pressures from 0-250 to 0-2000 psia or psig over wide temperature ranges, is described in new 2-page Bulletin P-61185.—Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y.

CIRCLE 317 ON READER-SERVICE CARD

CHOPPERS and their inspection and engineering measuring techniques are described in new 12-page instrument chopper catalog.—James Electronics, Inc., 4050 No. Rockwell St., Chicago 18, Ill.

CIRCLE 318 ON READER-SERVICE CARD

A/D CONVERTER "Capcoder" of high speed capacitive charge transfer type is described for serial or parallel operation in new 2-page bulletin.—Towson Laboratories, Inc., 200 E. Joppa Rd., Baltimore 4, Md.

CIRCLE 319 ON READER-SERVICE CARD

DIGITAL METERS. New all-electron "EItronic" series dc and ac/dc voltmeters, ratiometers and ohmmeters are described in 8-page bulletin D516.—Electro Instruments, Inc., 8611 Balboa Ave., San Diego 11, Calif.

CIRCLE 320 ON READER-SERVICE CARD

COMPUTER Program for designing lens for Nortronics ballistics camera using Bendix G-15 computer is given in new 4-page application report.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 321 ON READER-SERVICE CARD

OPTICAL GLOSSARY covering terms from "aberrations" to "surface reflection" is available in 1-page sheet.—Servo Corporation of America, 111 New South Road, Hicksville, L. I., N. Y.

CIRCLE 322 ON READER-SERVICE CARD

ZOOMAR ITV Mark IV and Mark VI lens data and instructions are available in new 4-page folder.—Zoomar, Inc., Glen Cove, N. Y.

CIRCLE 323 ON READER-SERVICE CARD

INFRARED transmitting materials are reviewed with transmission curves and detailed physical properties on each in new 4-page folder.—Servo Corporation of America, 111 New South Road, Hicksville, L. I., N. Y.

CIRCLE 324 ON READER-SERVICE CARD

POTENTIOMETERS. Precision types in linear/non-linear, ½" to 12" dia, translatory, sine-cosine, etc., are described in new series of 8 technical data sheet.—Accuracy, Inc., 223 Crescent St., Waltham 54, Mass.

CIRCLE 325 ON READER-SERVICE CARD

TRIMMING POTS, key information on key characteristics of 20 Trimpot adjustment potentiometers is given in 4-page brochure No. 7.—Bourns, Inc., TRIMPOT® Div., 6135 Magnolia Ave., Riverside, Calif.

CIRCLE 326 ON READER-SERVICE CARD

SQUARE TRIMMING pots are described with characteristics in new 4-page catalog of 1544 models.—Potentiometer Div., Daystrom Inc., Archbald, Pa.

CIRCLE 327 ON READER-SERVICE CARD

MULTITURN POT series 3700 is described in new 2-page technical bulletin.—Duncan Electronics, 2865 Fairview Rd., Costa Mesa, Calif.

CIRCLE 328 ON READER-SERVICE CARD

POTS, Seven composition element series, including three MIL-Spec series are described in new 16-page catalog.—Clarostat Mfg. Co., Inc., Dover, New Hampshire.

CIRCLE 329 ON READER-SERVICE CARD

TRIMPOT® POTENTIOMETERS are detailed with specifications in quick-reference, tabular 4-page folder.—Schweber Electronics, 60 Herricks Rd., Mineola, L. I., N. Y.

CIRCLE 330 ON READER-SERVICE CARD

PRECISION POTS, Single turn wire wound types in linear, non-linear, and sine-cosine configurations are described with performance data in new 6-page brochure.—Fairchild Controls Corp., 225 Park Ave., Hicksville, L. I., N. Y.

CIRCLE 331 ON READER-SERVICE CARD

TRIMMING POT with ⅜" square conformation is described in new 2-page catalog sheet.—Techno-Components Corp., 18232 Parthenia St., Northridge, Calif.

CIRCLE 332 ON READER-SERVICE CARD

WIREWOUND PRECISION epoxy encapsulated resistors in subminiature (1/10 watt) to 2" long (2 watt) sizes, non-inductive pi-wound, are described in new 9-page catalog.—Hamby Corporation, 7241 Eton Ave., Canoga Park, Calif.

CIRCLE 333 ON READER-SERVICE CARD

MINIATURE RESISTORS of Metallic Oxide, said to be most economical and smallest to meet MIL-R-10509 are described in new 2-page data sheet CE2.00.—Corning Electronic Components, Corning Glass Works, Bradford, Pa.

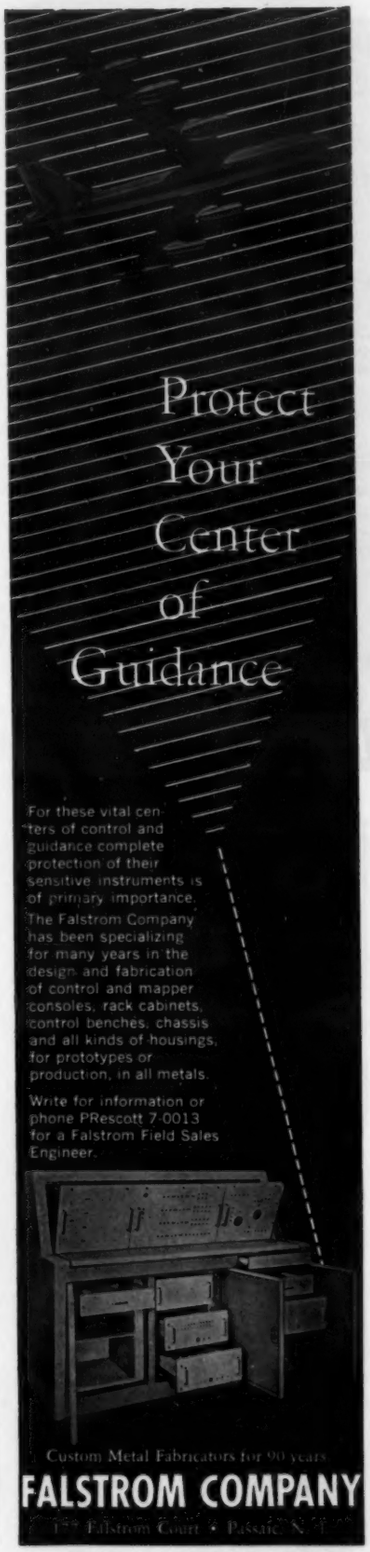
CIRCLE 334 ON READER-SERVICE CARD

TELEPHONE JACKS and plugs (including MIL-Spec series), and a series of miniature and sub-miniature jacks and plugs are described in 4-page technical bulletin #7010.—The Ucinite Co., Div. of United-Carr Fastener Corp., Newtonville 60, Mass.

CIRCLE 335 ON READER-SERVICE CARD

TIME DELAY RELAY specifications with full-scale drawings for tracing catalog.—Jordan Electronics, Div. of Victoreen Inst. Co., Alhambra, Calif.

CIRCLE 336 ON READER-SERVICE CARD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CIRCLE 77 ON READER-SERVICE CARD

PLANAR process semiconductors and production of the oxide-protected junctions which result from the Planar process to provide highly reliable and stable transistors and diodes are described in new 12-page brochure.—Fairchild Semiconductor, 545 Whisman Rd., Mountain View, Calif.

CIRCLE 337 ON READER-SERVICE CARD

GERMANIUM GOLD BANDED subminiature glass diodes, including computer types, high reverse resistance types, and high forward conductance types are specified and color coding information for all National Transistor diodes is given in new 4-page Bulletin A-101.—National Transistor Manufacturing, Inc., 500 Broadway, Lawrence, Mass.

CIRCLE 338 ON READER-SERVICE CARD

MICRO-DIODES in fast recovery, ultra-fast recovery and general purpose types are described with characteristics in three 2-page bulletins 102, 103 and 104 respectively.—Micro Semiconductor Corp., 11250 Plaza Ct., Culver City, Calif.

CIRCLE 339 ON READER-SERVICE CARD

GERMANIUM Diode line in both gold bonded and indium bonded types is described in 4-page Bulletin 515.—Electron Research, Inc., Div. of Erie Resistor Corp., 530 West 12th St., Erie, Pa.

CIRCLE 340 ON READER-SERVICE CARD

SEMICONDUCTOR PLANAR DEVICE parameters and characteristics are described in new 12-page catalog.—Fairchild Semiconductor, 545 Whisman Rd., Mountain View, Calif.

CIRCLE 341 ON READER-SERVICE CARD

SILICON CONTROLLED Rectifier industrial application are described in new 4-page applications bulletin GEA-7225.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 342 ON READER-SERVICE CARD

SEMICONDUCTOR COOLING by simultaneous heat transfer mechanisms of conduction, convection and radiation are discussed in new 11-page Heat Sink Application Manual. Nomograph for selection of heat sink to meet known conditions of temperature rise and watts dissipation is included.—Astro Dynamics, Inc., Second Ave., NW Industrial Park, Burlington, Mass.

CIRCLE 343 ON READER-SERVICE CARD

TRANSISTOR/DIODE multiples, including such devices as a chopper, differential amplifier, Darlington compound amplifier and photo transistor, are listed with schematic diagrams and lead configurations in new 44-page brochure.—Fairchild Semiconductor, 545 Whisman Rd., Mountain View, Calif.

CIRCLE 344 ON READER-SERVICE CARD

CLAD METALS for semiconductor manufacture, such as Gold-Indium clad, Kovar clad, Gold and Lead-Tin-Antimony-Germanium clad Nickel are described in new listing. Semi-Alloys, Inc., 20 North MacQuesten Pkwy, Mount Vernon, N. Y.

CIRCLE 345 ON READER-SERVICE CARD

CERAMIC DIODE-CLOSURE meeting MIL Specs and providing advantages over conventional glass-to-metal seal closures as well as epoxy packages is described in 2-page Tech bulletin M-103.—Metalizing Industries, Inc., 338 Hudson St., Hackensack, N. J.

CIRCLE 346 ON READER-SERVICE CARD

RETENTION/COOLING Devices including tube clamps, tube top-holding retainers, clamps for miniature plug-in tubes and components, JAN shield inserts for tubes, transistor retaining clips, and transistor/component heat radiators are described with data in new 8-page 1-W.—The Birtcher Corp., Industrial Div., 745 S. Monterey Pass Rd., Monterey Park, Calif.

CIRCLE 347 ON READER-SERVICE CARD

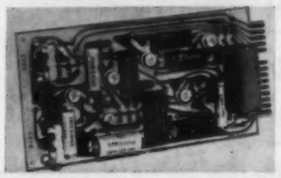
SUBMINIATURIZATION Services, including photography, electro-etching and metal deposition for manufacturers of microminiature products, are described in new 4-page brochure, "New Dimensions in Subminiaturization."—Tri-Lab Electronics, Inc., 4319 Twain Ave., San Diego 20, Calif.

CIRCLE 348 ON READER-SERVICE CARD

DUST-FREE ENCLOSURES. Vacuum Dry Boxes and Pressurized Dry Boxes are described in series of five 2-page Technical Bulletins.—S. Blickman, Inc., Weehawken, N. J.

CIRCLE 349 ON READER-SERVICE CARD

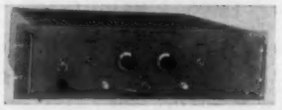
CHOPPER AMPLIFIER



New Series 200 chopper stabilizing amplifier features balanced input, single-ended output and may be used as an inverting or non-inverting amplifier, to replace tube-type carrier amplifiers.—*C.E.S. Electronic Products, 5026 Newport Ave., San Diego 7, Calif.*

CIRCLE 350 ON READER-SERVICE CARD

PULSE GENERATOR



New Pulse Generator Model 5-6826P providing 300 to 450 volts for loads up to 250 ma peak may be internally modulated at rates adjustable from 10 to 10,000 pps or externally triggered with a 20 volt peak pulse.—*Alfred Electronics, 3176 Porter Dr., Standard Industrial Park, Palo Alto, Calif.*

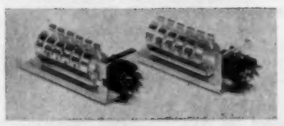
CIRCLE 351 ON READER-SERVICE CARD

RF ATTENUATOR

New high power radio frequency attenuators, Model AX-100, 100 watts, and Model AX-500, 500 watts with accuracy of ±.3 db for the dc 700 mc range is available in standard attenuations of 10, 20 and 30 db.—*Electro Impulse Laboratory, Inc., 208 River St., Red Bank, N. J.*

CIRCLE 352 ON READER-SERVICE CARD

COOLING RETAINERS



New 7B series Kool Klamps for subminiature T-3 tube envelopes are available with or without sockets for in-line and circular basing.—*The Birtcher Corp., Industrial Div., 745 S. Monterey Pass Rd., Monterey Park, Calif.*

CIRCLE 353 ON READER-SERVICE CARD

MINIATURE COMPRESSORS

New miniature compressors weigh between 3 to 8 pounds complete with motor and provide pressures to 100 psig and volumes to 3 scfm for cooling electronic devices, radar pressurization, microwave transmission lines, dry box-purging, and cable pressurization.—*Applied Pneumatics, Ind., 740 Colfax Ave., Kenilworth, N. J.*

CIRCLE 354 ON READER-SERVICE CARD

AUDIO BAND PASS

New band pass filters, Circuit-Dyne series FBH 102, utilize toroid coils exclusively as inductor elements, to cover frequency range of 255 to 3655 cps. The filters have a bandwidth of approximately 10% to 30% of center frequency at the 3 db down point.—*CircuitDyne Corp., 480 Mermaid Ave., Long Beach, Calif.*

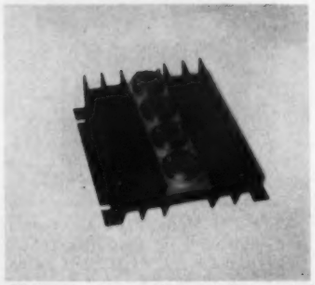
CIRCLE 355 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

New Barocel, for sensing gas pressure from below 1 micron to 25# as in angle attack indicators, altimeters, relative air speed transducers, etc., consists of a thin metal diaphragm stressed with approximately 60,000# and supported between two capacitor plates. Pressure differential is sensed as a voltage ratio change.—*Datametrics, Inc., 87 Beaver St., Waltham 54, Mass.*

CIRCLE 356 ON READER-SERVICE CARD

HEAT SINKS



Natural convection coolers made from type #6063-T5 aluminum provide excellent heat dissipation. Open area allows for access and ease in mounting transistors, zener diodes, silcon control rectifiers, and power rectifiers and diodes.—*Anderson Machine, Inc., 50 Brook Rd., Needham Heights, Mass.*

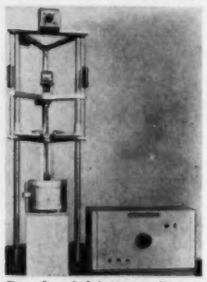
CIRCLE 357 ON READER-SERVICE CARD

COAXIAL ISOLATOR

New series of lightweight coaxial isolators are lightweight units which meet MIL Specifications standards over a temperature range of −30° to 85°C in the frequency range of 0.95 kmc to 3.1 mc.—*E & M Laboratories, 15145 Califa St., Van Nuys, Calif.*

CIRCLE 358 ON READER-SERVICE CARD

CRYSTAL PULLER



New Czochralski-type Crystal Puller designed by Hughes Aircraft Company Semiconductor Research Labs. is available in laboratory model to meet the requirements of solid-state research and development for the growing and pulling of elemental and compound semiconductor materials.—*Allen-Jones, Inc., 1345 Gaylord St., Long Beach, Calif.*

CIRCLE 359 ON READER-SERVICE CARD

TRANSISTORIZED INVERTERS

New light-weight solid-state inverters with efficiency ratings in excess of 80% in twelve models range from 30 to 500 watts output.—*Dynamic Instrument Corp., Syosset, N. Y.*

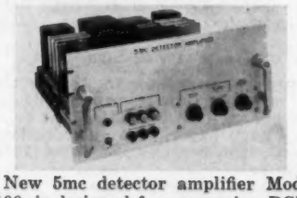
CIRCLE 360 ON READER-SERVICE CARD

COAX ADAPTER

A new line of Waveguide-to-coaxial adapters, with type N male and female connectors are available in waveguide sizes from WR187 (3.95 - 5.85 Gc) to WR28 (26.5 - 40.0 Gc).—*American Electronic Labs., Inc., Richardson Rd., Colmar, Pa.*

CIRCLE 361 ON READER-SERVICE CARD

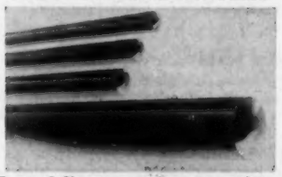
DETECTOR AMPLIFIER



New 5mc detector amplifier Model 5100, is designed for recovering PCM, PAM, and FM telemetry signals which have been hetrodyned to a standard 5mc IF frequency. A high-gain wideband dc amplifier following the discriminator is capable of driving a long 75 ohm coaxial line.—*Dynatronics, Inc., P. O. Box 4369, Panorama City, Calif.*

CIRCLE 362 ON READER-SERVICE CARD

RUBY OPTICAL MASERS



Fast delivery on large variety of lapped ruby optical maser rods in sizes up to 3" in length at 0°; up to 2½" long at 90° orientation; and up to ⅝" diameter x 7⅛" long for standard orientation. Doping is .04% chrome by weight, with nine other dopings available.—*Adolph Meller Company, Box 6001, Providence, R. I.*

CIRCLE 363 ON READER-SERVICE CARD

CAPACITORS, POLYSTYRENE dielectric characteristics are compared with other types in new 4-page tech bulletin 2-61.—Arco Electronics, Inc., Great Neck, N. Y.

CIRCLE 364 ON READER-SERVICE CARD

CAPACITORS, SILICONE rubber encapsulated wafer types are described in 2-page bulletins, #703.—Capacitron Div., AMP Incorporated, Elizabethtown, Pa.

CIRCLE 365 ON READER-SERVICE CARD

CERAMIC DISC Capacitor Transcap®, in capacitors of .05 μf, .1 μf, .2 μf, 25Vdcw; are described in new 2-page bulletin NP-120.—Erie Resistor Corp., 644 West 12th St., Erie, Pa.

CIRCLE 366 ON READER-SERVICE CARD

TANTALUM FOIL Capacitors, 85° "A"-case Tantalytic® type are described in new 2-page bulletin GEA-7226.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 367 ON READER-SERVICE CARD

CAPACITORS with Mylar, Mylar-paper, polysyrene and other dielectrics are described with engineering specs in new 27-page catalog.—Chicago Condenser Corp., 3255 W. Armitage Ave., Chicago 47, Ill.

CIRCLE 368 ON READER-SERVICE CARD

CAPACITORS for Kilovolt applications are described in two 2-page bulletins: GS type for RF and pulse application, 2.5 to 30 KV dc and Type BE for 50 to 250 KV applications.—Corson Electric Mfg. Corp., 540 39th St., Union City, N. J.

CIRCLE 369 ON READER-SERVICE CARD

SINTERED TANTALUM capacitors with solid electrolyte in sealed case with axial leads are described with spec test procedure in new 14-page Tantacon bulletin 511.—Erie Resistor Corp., 644 West 12th St., Erie, Pa.

CIRCLE 370 ON READER-SERVICE CARD

TANTALUM CAPACITORS, New non-polar solid electrolyte type STAN are listed with specifications in new 2-page bulletin 6.114.—Rectifier-Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.

CIRCLE 371 ON READER-SERVICE CARD

TANTALUM SLUG and foil capacitors. Ohmite exact electrical and electrical equivalents are listed opposite MIL designations and other make capacitor numbers arranged in sequence in new 6-page engineering bulletin 1009.—Ohmite Manufacturing Co., 3601 Howard St., Skokie, Ill.

CIRCLE 372 ON READER-SERVICE CARD

BUTTON® mica capacitors operating from −50°C through 200°C and now available with flag—type terminals are described in new 10-page bulletin 500-1.—Erie Resistor Corp., 644 West 12th St., Erie, Pa.

CIRCLE 373 ON READER-SERVICE CARD

CAPACITORS, High capacitance solid tantalum types providing up to 4000 μf at 6v dc working, are described in new 2-page bulletin 6.113.—Rectifier Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.

CIRCLE 374 ON READER-SERVICE CARD

POROUS-ANODE Tantalytic® capacitors in new extensions of standard line are described with outline drawings and performance curves in new 4-page bulletin GEA-7008B.—General Electric, Schenectady 5, N. Y.

CIRCLE 375 ON READER-SERVICE CARD

TANTALUM CAPACITORS of new and improved tubular sintered-anode type offering high reliability, resistance to shock and vibration, extremely low leakage and operation at wide temperature ranges are described in new 8-page bulletin ET-8.—Capacitor Div. of General Instrument Corp., Orange St., Darlington, S. C.

CIRCLE 376 ON READER-SERVICE CARD

TRIMMER CAPACITORS of variable piston type are described in new 24-page catalog C-61.—JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N. Y.

CIRCLE 377 ON READER-SERVICE CARD

ELECTRONIC PRODUCTS, together with addresses of Raytheon divisions are listed in new 8-page facilities brochure, entitled "Raytheon Spans the Frequency Spectrum."—Raytheon Co., Lexington 73, Mass.

CIRCLE 378 ON READER-SERVICE CARD

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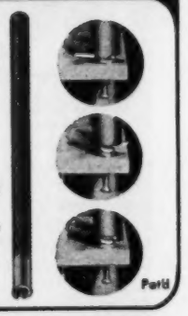

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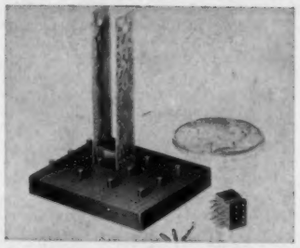
CIRCLE 79 ON READER-SERVICE CARD

MULTILAYER COMMUTATORS

Encoder discs, multi-layer commutators and switching plates using thin film techniques and patented transfer process guarantee flushness of wiping surface to less than one micron and dimensional tolerances of .0002" in 40".—*Intellux, Inc.*, 30 *South Salsipuedes St., Santa Barbara, Calif.*

CIRCLE 379 ON READER-SERVICE CARD

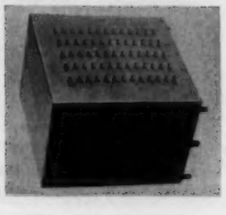
MICROMODULE CONNECTOR



New idea connector gives 256 terminations in 2" x 2¼" block, or two printed circuit cards on each of sixteen connector plugs. Components may be mounted on or between circuit boards for high density packaging.—*National Connector Corp., Science Industry Center, Minneapolis 27, Minn.*

CIRCLE 380 ON READER-SERVICE CARD

DELAY NETWORK



New Type CTC-1068 "Q-Line" with overall delay of 6.3 μsec has 8 mc bandwidth at an impedance level of 200 ohms. Rise time is 0.08 μsec. 63 taps are provided at 0.1 μsec intervals, and the T/C of delay is 30 PPM/°C. Meets environments Specification MIL-STD-202B.—*Columbia Technical Corp., Woodside 77, N. Y.*

CIRCLE 381 ON READER-SERVICE CARD

SHAKER, Model L-200, with force rating of 22,000 lb in 5-2000 cps full rating with any mass rating is described in new 2-page bulletin.—Ling-Temco-Vought, Inc., Ling Electronics Div., 1515 S. Manchester Ave., Anaheim, Calif.

CIRCLE 382 ON READER-SERVICE CARD

RANDOM-NOISE Generators with Model 301 Universal Power Supply for lab or field measurements of noise figure and receiver sensitivity are described in new 2-page bulletin.—General Microwave Corp., 47 Gazza Blvd., Farmingdale, N. Y.

CIRCLE 383 ON READER-SERVICE CARD

TRANSISTOR TRANSFORMER Load Impedance and Dissipation 2-page nomograph for use in design of Class A and Class B transformer-coupled transistor audio and servo amplifiers is available on request.—Microtran Co., Inc., 145 East Ave., Valley Stream, N. Y.

CIRCLE 384 ON READER-SERVICE CARD

TRANSFORMER Color Code Chart for power, audio, output and IF transformers is 8½" x 11" for wall or file use.—Mr. Bennett Cook, Stancor Electronics, Inc., 3501 Addison St., Chicago 18, Ill.

CIRCLE 385 ON READER-SERVICE CARD

TRANSFORMER and Inductors, full line meeting MIL-Specs is described, with section on effect of customer specification on design, in new 28-page bulletin GEA-7121.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 386 ON READER-SERVICE CARD

INDUCTORS, electrically variable by saturating core principle are described and characteristics specified in new 15-page catalog 61.—Vari-L Company, Inc., P. O. Box 1433, Stanmford, Conn.

CIRCLE 387 ON READER-SERVICE CARD

MAGNETOSTRICTIVE DELAY line Type 192 giving 20 to 2100 μsec delay is described with typical application circuit in 2-page catalog sheet.—Deltime Inc., 608 Fayette Ave., Mamaroneck, N. Y.

CIRCLE 388 ON READER-SERVICE CARD

FILTERS for telemetering, band pass, high pass, low pass, line and other filter applications are described with response curves in new 2-page engineering bulletin 602.—Stancor Electronics, Inc., 3501 West Addison St., Chicago 18, Ill.

CIRCLE 389 ON READER-SERVICE CARD

DELAY LINES of all currently popular types are described, simplified theories of operation are shown, applications are discussed and attainable characteristics are related to size and prices in 4-page paper, "An Introduction to Delay Lines."—Computer Devices Corp., 6 West 18 St., Huntington Station, N. Y.

CIRCLE 390 ON READER-SERVICE CARD

COILS miniature, epoxy molded and conventional forms and high voltage power packs are described in new 6-page folder.—Wabash Magnetics, Inc., Wabash, Ind.

CIRCLE 391 ON READER-SERVICE CARD

SELECTOR SWITCH. New Uniplane multi-circuit selector switch and general advantages of monoplanar switching over conventional methods is discussed in two 4-page bulletins (#6130 and #6131).—The Ucinite Co., Div. of United-Carr Fastener Corp., Newtonville 60, Mass.

CIRCLE 392 ON READER-SERVICE CARD

EPOXY ENCAPSULATING and potting of critical parts and assemblies, and properties of nine special epoxy resin potting components are described in six 4-page data bulletins.—Bacon Industries, Inc., 192 Pleasant St., Watertown, 72, Mass.

CIRCLE 393 ON READER-SERVICE CARD

SHEET METAL fabrications, including chassis, cabinets, racks, etc., are listed and described in new 21-page catalog 61-62.—California Chassis Co., 5445 E. Century Blvd., Lynwood, Calif.

CIRCLE 394 ON READER-SERVICE CARD

HELIXING LATHES for helixing metal, carbon, and oxide films on glass or ceramic resistor blanks are described in new 4-page catalog.—Industrial Instruments Automation Corp., 89 Commerce Road, Cedar Grove Essex County, N. J.

CIRCLE 395 ON READER-SERVICE CARD

PARTICLE MONITOR, digital Model PC-200A for the continuous, unattended size/concentration analysis of airborne particulates is described in a new 2-page leaflet.—Royco Instruments, Inc., 440 Olive St., Palo Alto, Calif.

CIRCLE 396 ON READER-SERVICE CARD

WIDEBAND DC AMPLIFIER

New PM Model 3102 all-transistorized wideband dc amplifier features: Less than 1μv/°C drift; 0.01 gain stability; 50 megohms input impedance; 0.06 ohms output impedance linearity of ±0.02% of output; fixed or adjustable gains from 10 to 1000 or higher.—*P/M Electronics, Inc.*, 5221 *University Ave., San Diego 5, Calif.*

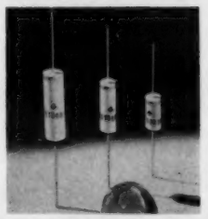
CIRCLE 397 ON READER-SERVICE CARD

VHF-UHF NOISE GENERATOR

New VHF-UHF Noise Generator 904-A measures receiver and amplifier noise factors in the VHF-UHF range from 30 to 1000 mc. Noise figures between 0 and 20 db are read directly, or can be extended beyond 20 db by simple calculations.—*PRD Electronics, Inc.*, 202 *Tillary St., Brooklyn 1, N. Y.*

CIRCLE 398 ON READER-SERVICE CARD

COMPENSATED ZENERS



New line of high voltage temperature compensated zener reference diodes at 26 voltages ranging from 18.5 to 200 volts (V_z @ I_zt), feature T/C's of .005%/°C Max with a ±5% maximum tolerance on nominal zener voltage, meeting MIL-S-19500B.—*Dickson Electronics Corp.*, 248 *Wells Fargo Ave., Scottsdale, Ariz.*

CIRCLE 399 ON READER-SERVICE CARD

2-IN-1 TRACKING SYSTEM

New Zoomar 2-in-1 Tracking System integrates the IV 40" Zoomar-Reflectar and Zoomar Trulex Automatic exposure control with a 35-mm pulse camera and a specially "ruggedized" vidicon TV camera which can be operated by remote control at a considerable distance from the installation.—*Zoomar, Inc.*, 55 *Sea Cliff Ave., Glen Cove, N. Y.*

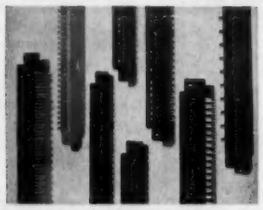
CIRCLE 400 ON READER-SERVICE CARD

NARROW LIMIT STAT

New thermostat, Type M2, giving temperature control within 2°-5°F over the 0-250°F range utilizes a bimetallic, snap-acting KLIXON® disc actuating fine silver contacts. Assembly is hermitically welded in a flat, nickel-plated steel shell.—*Metals & Controls, Inc., Div. of Texas Inst., Inc.*, 34 *Forest St., Attleboro, Mass.*

CIRCLE 401 ON READER-SERVICE CARD

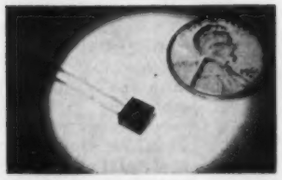
PRINTED CIRCUIT CONNECTORS



New line of bifurcated bellows-type printed circuit connectors provides complete and continuous contact for various multiples up to 130 contacts, even when subjected to extremes of vibration and shock.—*Masterite Industries*, 871 *W. Olive St., Inglewood, Calif.*

CIRCLE 402 ON READER-SERVICE CARD

SUBMIN TOROIDS



New plug-in subminiature toroidal inductors; Series 91 for vhf and Series 92 for hf applications, have a volume of 0.004 cu-in, are vacuum-encapsulated in epoxy, and meet specification MIL-C-15305B, Grade 1, Class B (−55°C to 125°c).—*Vanguard Electronics Co.*, 3384 *Motor Ave., Los Angeles 34, Calif.*

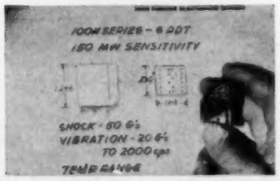
CIRCLE 403 ON READER-SERVICE CARD

VOLTAGE COMPARATOR

New 10-oz transistorized voltage monitor Model VC670 continuously compares a random signal with an external reference and provides a fail-safe alarm when the signal value exceeds the external reference limit.—*VERCO, Inc.*, 1430 130*th N.E., Bellevue, Wash.*

CIRCLE 404 ON READER-SERVICE CARD

MICRO RELAYS



New sensitive, 6PDT, 100 N Series micro-miniature relays for dry circuit to high level switching conform to and exceed the test specifications of MIL-R-5757D and feature bifurcated contact construction for longer life and greater reliability.—*Electronics Div., Iron Fireman Manufacturing Co.*, 2838 *S. E. 9th Ave., Portland 2, Ore.*

CIRCLE 405 ON READER-SERVICE CARD

RADOME, Antenna Boresight Measuring System is described in new 4-page Bulletin R1000, Dunn Engineering Corp., 225 O'Brien Highway, Cambridge 41, Mass.

CIRCLE 406 ON READER-SERVICE CARD

"MICROWAVE SYSTEM Phase Characteristics Analysis and Measurement" is subject of 9-page engineering paper by Peter Lacy, free on request.—The Wiltron Co., 717 Loma Verde Ave., Palo Alto, Calif.

CIRCLE 407 ON READER-SERVICE CARD

PREAMPLIFIERS, VHF ultra-low-noise "PRV" units using GE 7077 ceramic planar triodes with 6 mc band pass are described in new 4 page bulletin.—Community Engineering Corp., State College, Pa.

CIRCLE 408 ON READER-SERVICE CARD

KLYSTRONS (High- and Low-power) Ceramic and glass electron power tubes and sockets are described in new 48-page quick reference catalog.—Eitel-McCullough, Inc., San Carlos, Calif.

CIRCLE 409 ON READER-SERVICE CARD

VARIABLE PIEZOELECTRIC transducers (Variducers) utilizing barium titanate and lead zirconate elements are described in new 2-page specification sheet.—Sensinocs, Inc., 952 Shoreham Bldg., Washington 5, D. C.

CIRCLE 410 ON READER-SERVICE CARD

VACUUM High voltage and RF switches and capacitors using vacuum dielectric are described in new 8-page catalog of Vacuum Components.—Jennings Radio Mfg. Corp., 970 McLaughlin Ave., P. O. Box 1278, San Jose 8, Calif.

CIRCLE 411 ON READER-SERVICE CARD

MICROWAVE signal generators available in stabilized models covering the frequency ranges from the L-Band (1.0-2.0 kmc) to the Ka-Band (32.0-37.0 kmc) are described in new 2-page bulletin SDS3.—Strand Labs, Inc., 294 Centre St., Newton 58, Mass.

CIRCLE 412 ON READER-SERVICE CARD

"CRYSTAL Controlled Oscillators, How to Specify," is subject of new 4-page booklet.—Monitor Products Co., Inc., 815 Fremont Ave., South Pasadena, Calif.

CIRCLE 413 ON READER-SERVICE CARD

OSCILLATORS, 2 kc to 100 mc, for missile and satellite applications, in series of four miniature transistorized units, are described in new 2-page catalog sheet.—Electronics Div., Bulova Watch Co., Inc., 40-01 61st St., Woodside 77, N. Y.

CIRCLE 414 ON READER-SERVICE CARD

U-BAND two-cavity klystron oscillators for parameter amplifier pumping and doppler radar amplifications are described in new 4-page brochure.—Mr. Warren L. Vergason, Sec. 101, Sperry Electronic Tube Div., Gainesville, Fla.

CIRCLE 415 ON READER-SERVICE CARD

WAVEGUIDE of oxygen-free high conductivity copper, in nine commonly used sizes, is listed in new 4-page waveguide bulletin 8483.—Andrew Corp., P. O. Box 807, Chicago 42, Ill.

CIRCLE 416 ON READER-SERVICE CARD

ANTENNAS Broadband Vertical radiators for 2-6mc, 4.5-13.4 mc, etc. are described in new 2-page Trylon bulletin.—Wind Turbine Co., West Chester, Pa.

CIRCLE 417 ON READER-SERVICE CARD

MICROWAVE communications systems, countermeasures equipment, spectrum surveillance systems, microwave components and instruments, are described in new 6-page catalog No. 861.—Melabs, 3300 Hillview Ave., Standford Industrial Park, Palo Alto, Calif.

CIRCLE 418 ON READER-SERVICE CARD

PARABOLIC Antennas from 16' to 32' in diameter, designed for communications applications and including various feed systems are described in new 18-page Taco Catalog No. 500.—Technical Appliance Corporation, Sherburne, N. Y.

CIRCLE 419 ON READER-SERVICE CARD

UHF oscillators, frequency multipliers, and rf amplifiers for the design of satellite, missile and supersonic sled system transmitters are described in 4-page Bulletin ATC-1.—Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.

CIRCLE 420 ON READER-SERVICE CARD

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CIRCLE 80 ON READER-SERVICE CARD

FOR MORE INFORMATION ON PRODUCTS LISTED—CIRCLE THE CORRESPONDING NUMBER ON THE READER SERVICE CARD BOUND IN THIS BOOK

TRANSDUCER POWER Supply and Balance Units, Models PB-290 and PS-290 are described in new data sheet PB-1. —Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.

CIRCLE 421 ON READER-SERVICE CARD

PULSE GENERATORS and voltage sources designed for special applications are cited in 4-page catalog sheet to show capability and the Bulova technique of providing basic building-block type of components for applications such as frequency sources, time references, in doppler radar systems, and as the basis for communication and telemetry carrier frequencies.—Bulova Watch Co., Inc., Electronics Div., 40-01 61st St., Woodside 77, N. J.

CIRCLE 422 ON READER-SERVICE CARD

STATIC Inverter, in 100va airborne model providing 400 cps regulated sine wave output from 28vdc is described in 2-page engineering data sheet 90-156-0.—Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

CIRCLE 423 ON READER-SERVICE CARD

SWITCHING PRE-REGULATOR (an instrumentation which offers essentially lossless regulation) is explained including its application as a power supply pre-regulator in new 16-page catalog PS961.—Valor Instruments, Inc., 13214 Crenshaw Blvd., Gradena, Calif.

CIRCLE 424 ON READER-SERVICE CARD

RFI SHIELDING below 48 gc and free air cooling for electronic packages are combined in new Teckcell®, described in 2-page data sheet RF-16.—Technical Wire Products, Inc., 129 Dermody St., Cranford, N. J.

CIRCLE 425 ON READER-SERVICE CARD

HIGH TEMPERATURE wires, cables, tubings, etc. are listed with synopses of government wire specifications, new product high-lights, tabulations on applicable military specifications, U. L. listings and ratings and product characteristics in new 58-page catalog.—Hitemp Wires Co., A Div. of Simplex Wire & Cable Co., 1200 Shames Dr., Westbury, L. I., N. Y.

CIRCLE 426 ON READER-SERVICE CARD

NYLON-BASE laminated plastic Tayloron PN, recommended for rocket applications where temperatures may exceed 4000° F for short periods of time, and which features low specific gravity and thermal conductivity, is described in new 2-page bulletin 8.9.—Taylor Fibre Co., Norristown, Pa.

CIRCLE 427 ON READER-SERVICE CARD

ASBESTOS Reinforced plastic sheets, molded rods and tubes of high-temperature Tayloron PA are described with characteristics and standard sizes in new 2-page bulletin 8.5.—Taylor Fibre Co., Norristown, Pa.

CIRCLE 428 ON READER-SERVICE CARD

MULTIPLE CONDUCTOR Control Cables Constructed to MIL-W 16878C and shielded cables to MIL-C-7078A are described in 2-page data sheet.—National Wire and Cable Corp.

CIRCLE 429 ON READER-SERVICE CARD

P/C MOUNTING Enclosure, the TDC "Uni-Cage," for front loading racks or top mounting drawers and holding 24 printed circuit cards is described in new 2-page bulletin TDC-ccl.—Epsco Inc., 275 Massachusetts Ave., Cambridge, Mass.

CIRCLE 430 ON READER-SERVICE CARD

PYROTECHNIC special devices, including SOFAR Bomb, exploding bridgewire cartridges, frangible nut separation system and infrared tracking source are described in five new technical data bulletins.—Special Devices, Inc., 16830 W. Placerita Canyon Rd., Newhall, Calif.

CIRCLE 431 ON READER-SERVICE CARD

DRAFTING of repetitive symbols by use of pre-printed "Stanpat" symbols designed to your needs is explained in new 6-page pocket folder.—Stanpat Co., Whitestone 57, N. Y.

CIRCLE 432 ON READER-SERVICE CARD

FILM COATED magnet wire type test procedures, a compilation and summary of NEMA and MIL-W-583B specifications are covered in new 6-page bulletin MW-1000. —Hudson Wire Company, Magnet Wire Div., Winsted, Conn.

CIRCLE 433 ON READER-SERVICE CARD

DIRECT READING WAVEMETER

New Model RDW-2A(D) wavemeter, tunable 130-245mc, is one of a new series of direct reading search wavemeters covering the 130-8000 mc range. Readable accuracy is ±1 mc. —*Radar Design Corp., Pickard Dr., Syracuse* 11, *N. Y.*

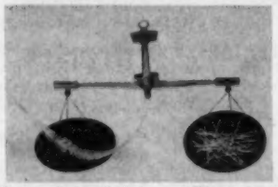
CIRCLE 434 ON READER-SERVICE CARD

BWO POWER SUPPLY

New power supplies for Backward Wave Oscillator tubes are provided in manual control styles for fixed operation or in remote-control styles for automatic system or equipment applications.—*Micro-Power, Inc.*, 20-21 *Steinway St., Long Island City* 5, *N. Y.*

CIRCLE 435 ON READER-SERVICE CARD

MICROMINIATURE RECTIFIERS



New microminiature silicon rectifiers only .075" long x .030" diameter with gold plated silver leads are rated at 250 ma average rectified current, 5 amperes surge current and 600 VIP, operate in ambients over 200°C.—*MicroSemiconductor Corporation*, 11250 *Playa Court, Culver City, Calif.*

CIRCLE 436 ON READER-SERVICE CARD

TANK CIRCUITS

Miniature tank circuits consisting of a precision miniature piston capacitor connected across an air core coil are available in five overlapping frequency ranges from 165 to 1000 mc. Nominal Q is in excess of 230, with many custom variations possible. —*JFD Electronics Corp.*, 6101 *Sixteenth Ave., Brooklyn* 4, *N. Y.*

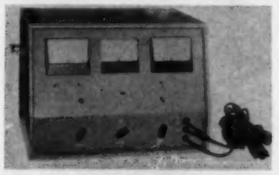
CIRCLE 437 ON READER-SERVICE CARD

DC AMPLIFIER

New low level "FIFO" (floating input-floating output) dc amplifier with 10 kc bandwidth can be used for amplifying high frequency data from wide bandwidth transducers or amplifying many channels of commutated information. Features gain of 1000, 100-meg input impedance min at dc, overload recovery time less than 1.0 msec, high common mode rejection, low noise and low drift.—*Sanborn Co., Industrial Div.*, 175 *Wyman St., Waltham* 54, *Mass.*

CIRCLE 438 ON READER-SERVICE CARD

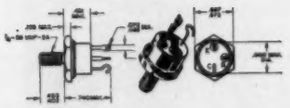
MILITARY HYPOT TESTER



New Model 4075 Hypot insulation breakdown and leakage test set meets requirements of MIL-T-27A by simultaneously testing two windings of a transformer by varying and measuring the test potential between the windings and between each winding and ground.—*Associated Research, Inc.*, 3777 *W. Belmont Ave., Chicago* 18, *Ill.*

CIRCLE 439 ON READER-SERVICE CARD

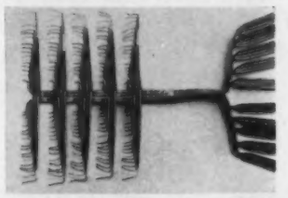
POWER TRANSISTORS



New 85-watt diffused junction NPN silicon power transistors 2N1208 and 2N1212 operating in the −65° to 200°C range qualify under MIL-S-19500B, have V_{ce} of 60 v, I_c of 5 amps.—*Silicon Transistor Corp., Carle Place, N. Y.*

CIRCLE 440 ON READER-SERVICE CARD

FLAT MULTI-CABLE



New Spectrastrip flat multiconductor cable lends itself to flat bonded harness having no strings to cut into insulation, gives identical interconductor capacitance in each harness.—*Spectra-Strip Wire & Cable Corp., P. O. Box* 415, *Garden Grove, Calif.*

CIRCLE 441 ON READER-SERVICE CARD

LOAD CELL

New load cell combining FluiDyne transducer (left) with rugged parallelogram flexure is called the Flex-Cell (right) which features deflections as low as .001", high frequency response, linearity of output and easy adaptation to test stand applications. —*FluiDyne Engineering Corp.*, 5740 *Wayzata Blvd., Minneapolis* 16, *Minn.*

CIRCLE 442 ON READER-SERVICE CARD

X-BAND SWITCH DIODE

New S150 germanium diode in 1N21 Type cartridge is designed for nanosecond switching in the X-band. Insertion loss at 9 Gc at zero bias is 16 db when mounted in transmission-type crystal holder; reduces to less than 1.5 db with 80 ma forward bias.—*Microwave Semiconductor & Instruments Inc.*, 116-06 *Myrtle Ave., Richmond Hill* 18, *N. Y.*

CIRCLE 443 ON READER-SERVICE CARD

TWIN FILAMENT LAMP

New Indicator lamp with two filaments, one with long-life characteristics, gives dimmed light to warn of need for replacement when normal-brightness filament burns out. Reduced light prevents complete failure of signal function.—*Chicago Miniature Lamp Works, Dept. IA-5*, 1500 *No. Ogden Ave., Chicago* 10, *Ill.*

CIRCLE 444 ON READER-SERVICE CARD

HIGH RESISTANCE RELAY

New MVT Series high-resistance coil military relay, available with coil resistances from 5 to 15 kilohms has a pull-in sensitivity of 250 mv at 25°C. DPDT contacts rated at 2 amp resistive, dry circuit contacts are also available on special order. Withstands 20G vibration from 34 to 2000 cps and 50G shock for 11 msec. —*Elgin Advance Relays*, 2435 *No. Naomi St., Burbank, Calif.*

CIRCLE 445 ON READER-SERVICE CARD

PRECISION GIMBAL BEARINGS

New gimbal bearings for missile guidance systems hold breakaway torque to less than 12 oz-in under 330 axial load. Eccentricities of raceways are 0.0003" or less, parallelism of sides of rings and raceways is held to .0002".—*Industrial Tectonics, Inc.*, 18301 *Santa Fe Ave., Compton, Calif.*

CIRCLE 446 ON READER-SERVICE CARD

PHOTOMULTIPLIER SUPPLY

New solid-state, Model AH Adjustable power supply for type 6199 photomultipliers in missile and space vehicle applications has built-in overload and protector circuits with external taps providing from 700 to 1500 v. Regulation of ±.25% over a temperature range of −40° to 80°C is obtainable. Standard models operate from 6-30v dc or 100 v pp 2400 cps square wave, weight 7 oz.—*Matrix Research & Development Corp., Nashua, N. H.*

CIRCLE 447 ON READER-SERVICE CARD

SUB-MIN CHASSIS

Sub-miniature chassis boards of mechanical precision closer than .0001" are now available in phenolics, nylon, Teflon, fibre, epoxy and silicone glass laminates and copper clad laminates.—*Die-Tech Corp., 29 Marble Ave., Pleasantville, N. Y.*

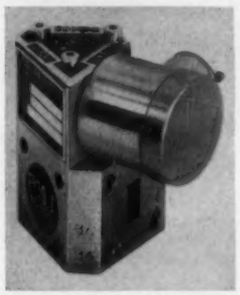
CIRCLE 448 ON READER-SERVICE CARD

SATELLITE TRANSFORMERS

New "Water Bug" subminiature pulse transformers are designed for satellite, space probe and missile applications where reliability, size and weight are critical. Model PT861 shown has turns ratios of 1:1:2.8, pulse width only 2.5 μsec.—*Valor Instruments, Inc.*, 13214 *Crenshaw Blvd., Gardena, Calif.*

CIRCLE 449 ON READER-SERVICE CARD

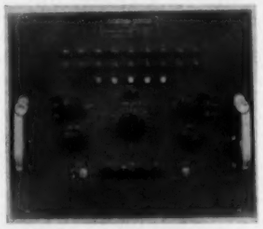
WAVEGUIDE SWITCH



New Micro-Delta millimeter band waveguide switches provide make-before-break switching of single waveguide input to either of two outputs. Switching VSWR is 2.1 max; operating VSWR for W-6KU (18 to 26.5 Gc) is 1.2 max, for Type W-6KT (26.5 to 40 Gc) is 1.3 max.—*Don-Lan Components Div., Microwave Laboratories, Quantron, Inc.*, 1131 *Olympic Blvd., Santa Monica, Calif.*

CIRCLE 450 ON READER-SERVICE CARD

TELEMETERING CALIBRATOR



New Model C-005 calibrator automatically checks all FM-FM subcarrier channels. Test signals derived from individual transistorized plug-in crystal oscillators automatically switch through center and end frequencies in each channel in proper sequence. Also operates in semi-automatic and manual modes.—*Probescope, Inc.*, 8 *Sagamore Hill Drive, Port Washington, N. Y.*

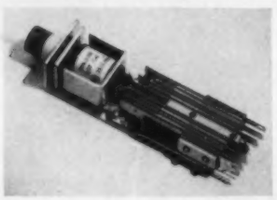
CIRCLE 451 ON READER-SERVICE CARD

PISTON CAPACITORS

New Piston type trimmer capacitors for vertical mounting on printed circuit boards reduce space required for manipulating trimming tools, also give more flexibility in placement. Available in 8.5, 10 and 12 pf ranges. —*Atlee Corp., Atlas Div.*, 2 *Lowell Ave., Winchester, Mass.*

CIRCLE 452 ON READER-SERVICE CARD

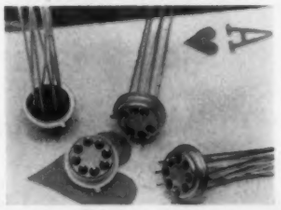
MAGNETIC PUSH BUTTONS



New magnetic push buttons are held in actuated position by tiny built-in electromagnets; release by switching off the holding current. Two-color button makes the button's on-off position easy to determine.—*Components Div., International Telephone and Telegraph Corp.*, 320 *Park Ave., New York* 22, *N. Y.*

CIRCLE 453 ON READER-SERVICE CARD

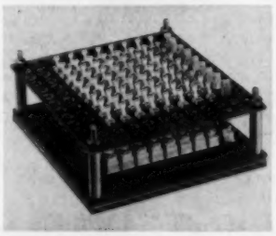
TRANSISTOR CLOSURES



Basic TO-5 transistor configuration closures now accommodate up to thirteen separate leads. Leads may be grounded or ungrounded, depending on design requirements, the header can be supplied with electrically isolated flat forms or "islands," or with a common body. These units are ideal for multiple transistor packages, self-contained logic circuits, diode networks, molecular wafers, and minature networks.—*Glass-Tite Industries, Inc.*, 727 *Branch Ave., Providence* 4, *R. I.*

CIRCLE 454 ON READER-SERVICE CARD

PROGRAM BOARD



New single-contact Sealectoboard provides common bussed line for combining individual inputs to distribution of combined output to isolated or associated circuitry. As control point for programming, it may be used as switching device or component interpositioner by use of Sealectoboard diode holders.—*Sealectro Corp.*, 139 *Hoyt St., Mamaroneck, N. Y.*

CIRCLE 455 ON READER-SERVICE CARD

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- An Aristo custom source may be the simple solution to that tough illumination problem

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- Inspection - Investigation - Research

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CIRCLE 83 ON READER-SERVICE CARD

BALANCED MIXER

New sidewall hybrid balanced mixer, Model 15MS16, using a 1N2792 crystal measures less than 3.000" in length, covers the frequency range 68.0-72.0 Gc with max VSWR:2.0—*Microwave Development Laboratories, Inc., Natick, Mass.*

CIRCLE 456 ON READER-SERVICE CARD

SILICON ZENER DIODES

The ASC Zener units shown passed the toughest shock, vibration, fatigue and acceleration tests and still perform to exacting specifications in a temperature range from −65°C to 150°C. Designed for circuits exposed to severe environments.—*American Semiconductor Corp.*, 3940 *N. Kilpatrick Ave., Chicago* 41, *Ill.*

CIRCLE 457 ON READER-SERVICE CARD

POSITION TRANSDUCER

New line of precison transducers translate large mechanical deflections into accurate linear voltage changes. An infinite resolution potentiometer accurate to .01% is available in various sizes for up to 120 ft linear displacement.—*Lockheed Electronics Co., Avionics & Industrial Products Div.*, 6201 *E. Randolph St., Los Angeles* 22, *Calif.*

CIRCLE 458 ON READER-SERVICE CARD

LASER ROD COATING

New dielectric multilayer film coatings which are said to increase output gain to between 7-to-1 and 8-to-1 is available on new rods or can be applied to rods already in use. Multilayer films cannot burn at high energy, hence do not require cooling periods, have longer life.—*Adolf Meller Co., Providence, R. I.*

CIRCLE 459 ON READER-SERVICE CARD

TRANSISTOR POWER MODULE

A high-precision plug-in module dc power source in eight models provides outputs ranging from 5-41 v at up to 3.5 amps. Regulation is 0.01% max. Ripple 500 μv max. Operating ambient temperature, 0-50°C in still air without heat sink and with no derating.—*ACDC Electronics, Inc.*, 2979 *N. Ontario St., Burbank, Calif.*

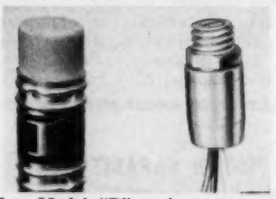
CIRCLE 460 ON READER-SERVICE CARD

HOT/COLD PROGRAMMER

New program controller for temperature chamber performance in accordance with MIL-STD 202B Method 102A and 107A, starts on cold cycle, holding at any temperature from −75°C to 0°C up to 3 hours; heats to 25°C and holds 15 minutes; heats to high temperature from 50° to 315°C, holding for time equal to cold period then is cooled to ambient and held for 15 minutes to complete one cycle. The program repeats until cycle timer stops sequence.—*Delta Design, Inc.*, 3163 *Adams Ave., San Diego* 16, *Calif.*

CIRCLE 461 ON READER-SERVICE CARD

HOT MOLDED CARBON POTS



New Model "P" carbon pots meeting all the environmental and test requirements of MIL-R-94B (Style RV6), has a hot molded resistor track molded into its insulating base. A cold-formed anodized aluminum alloy case is swaged to the molded insulation at the back of the unit to provide a near perfect seal. A single solid carbon brush acts as both pick-up and collector brush. One side of the brush rests upon the resistance track and the other upon a silver plated terminal.—*Centralab Div., of Globe-Union, Inc.*, 900 *East Keefe Ave., Milwaukee* 1, *Wis.*

CIRCLE 462 ON READER-SERVICE CARD

TEFLON FUEL BLADDERS

New Teflon® fuel expulsion bladders and diaphragms offer complete impermeability to chemical attack from various exotic (hot) fuels and oxidizers (UDHM, MON, Nitrogen Tetroxide, etc.) . . . remain flexible and sturdy throughout a wide temperature range and other challenging environmental conditions and conveniently lend themselves to mechanical adaptation while presenting a negligable weight factor.—*Dielectric Corp.*, 69 *Allen Blvd., Farmingdale, L. I., N. Y.*

CIRCLE 463 ON READER-SERVICE CARD

STEAM CONTROL VALVES

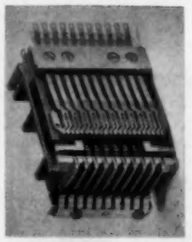
Automatic control feature used on two 1000 psi six-inch steam control valves for new aircraft carrier, USS CONSTELLATION, steam catapult "dumper" valve application is shown. Other 8" General Controls valves automatically fill the catapult to steam pressure required by the weight of the load to be launched.—*General Controls Co., Warwick, R. I.*

CIRCLE 464 ON READER-SERVICE CARD

TEMP COMPENSATED ZENERS

New line of silicon reference diodes covering a range of 5.9v through 300 v in temperatures from −55° to 100°C provide maximum voltage change accuracies of .01%, .005%, .001% and .0005%.—*American Semiconductor Corp.*, 3940 *N. Kilpatrick Ave., Chicago* 41, *Ill.*

CIRCLE 465 ON READER-SERVICE CARD



PULSE COUNTER

New Type ZM-53 electromagnetic pulse counter has ten relay-type armatures operate sequentially on application of a pulse series.—*Components Div., International Telephone and Telegraph Corp.*, 320 *Park Ave., New York* 22, *N. Y.*

CIRCLE 466 ON READER-SERVICE CARD

DECADING MATRIX PIN

Component holders providing contact points at any coordinate on an X- and Y-axis are now available for use with the Sealectoboard program board. Any two-lead component, less than 1/2" long X 1/8" in diameter, with leads of #22 AWG or smaller diameter, may be used in the Sealectoboard Component holder. The Sealectoboard when used with component holders becomes a decade, permitting additions or substractions of component effect on associated circuitry by merely pushing in various pin-type component holders.—*Sealectro Corp.*, 610 *Fayette Ave., Mamaroneck, N. Y.*

CIRCLE 467 ON READER-SERVICE CARD

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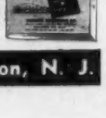

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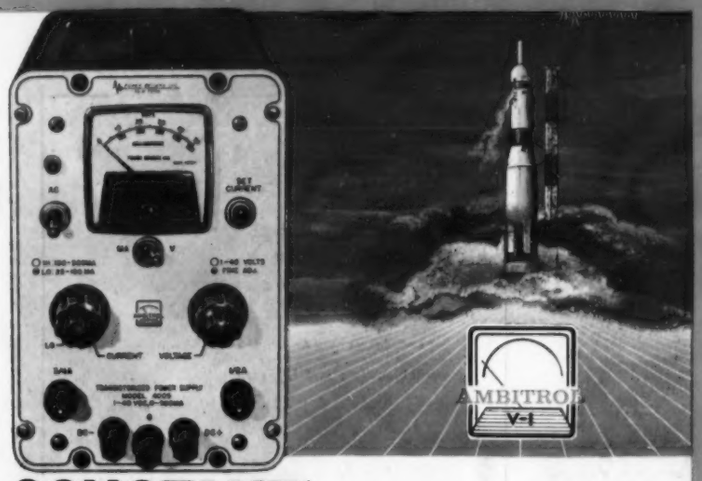

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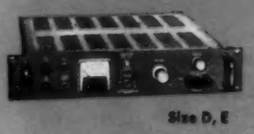
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FEBRUARY 6-7—Symposium on Redundancy Techniques for Computing Systems, Dept. of Interior Auditorium, Washington, D. C. Sponsored by ONR, Westinghouse Electric Corp. Open to all interested. Write Information Systems Branch—Code 437, ONR, Washington 25, D. C.

FEBRUARY 14-16—1962 International Solid-State Circuits Conference, Sheraton Hotel, Philadelphia, Pa., Sponsored by IRE-PG on Circuit Theory, AIEE Committee on Basic Sciences and Univ. of Penna. Write Lewis Winner, 152 W. 42nd St., New York 36, N. Y.

FEBRUARY 27-MARCH 1—Third Annual Symposium on Nondestructive Testing of Aircraft and Missile Components (Unclassified), Gunter Hotel, San Antonio, Texas. Sponsored by So. Texas Sect., Society for Nondestructive Testing, Inc., and Southwest Research Inst., Write Dr. Warren McGonnagle, Southwest Research Institute, Box 2296, San Antonio, Texas.

MARCH 26-29—IRE International Convention, Coliseum and Waldorf-Astoria Hotel, New York, N. Y. Write E. K. Gannett, IRE Headquarters, 1 East 79th St., New York 21, N. Y.

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